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A STUDY OF THE FIRST YEAR EGG PRODUCTION OF S. C. RHODE ISLAND REDS

V. S. ASMUNDSON

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During the past six years, considerable data in the form of individual egg records have accumulated for the strains of S. C. White Leghorns, S. C. Rhode Island Reds, Barred Rocks and White Wyandottes, bred on the poultry plant of the University of British Columbia. These four varieties were apparently selected on the assumption that they were the most important in Canada, as measured by popularity. This is borne out by entries in the fourth and fifth contests conducted by the Canadian Government on its Experimental Farms and Stations, for, of 6,610 birds entered, 2,500 (or 37.82 per cent) were B. P. Rocks, 2,410 (or 36.46 per cent) were White Leghorns, 900 (or 13.62 per cent) were White Wyandottes, and 330 (or 4.99 per cent) were S. C. Rhode Island Reds. Whilst considerably fewer birds were entered in the case of the S. C. Rhode Island Reds than in the case of any of the other varieties mentioned, the number entered was more than twice as great as that of any other less popular variety.

At the present time, comparatively few data are available on the distribution of first year egg production for different breeds in different parts of the North American continent or elsewhere. Reports by Elford and Taylor (1924, 1925) for the Canadian National Egg Laying Contests indicate that birds of different varieties submitted to the contests do not give the same average total production, and further that the average total production for the various contests differs widely. These facts would seem to show that it is desirable to have data on total and monthly egg production for the various breeds under different climatic conditions, to serve as a guide to indicate the production that may be expected or that can be secured. Data published by Goodale (1922) for the S. C. Rhode Island Reds at the Massachusetts Agricultural Experiment Station show that very considerable increases can be effected in egg production in this breed. Goodale (1922) was able to raise the production of the Massachusetts Reds to the point where their total average production was considerably above that reported by Dunn (1924) for Rhode Island Reds entered in the Storrs Contests. The data published in these reports will be referred to in the discussion that follows. These and other reports were freely drawn on for ideas as to the best methods of presenting the material here reported.

Object

The object of this paper is to present data on the egg-production of a flock of S. C. Rhode Island Reds owned by the University of British Columbia. The data have been arranged to give information about annual and monthly egg-production, the variability of egg-production in these periods, and the changes that have occurred in each case.

Materials and Methods

This study is based on the trapnest records of 510 S. C. Rhode Island Red pullets, hatched, reared and trapnested on the poultry plant of the University of British Columbia. All the pullets were hatched in March, April or May, 1920 to 1925 inclusive. The birds were selected to some extent before banding, and the poorest specimens discarded. In some years, there was, however, little or no choice, since an attempt was made to retain at least 100 birds each year. After the pullets were banded, all birds that lived were retained until October 31st of the following year, except in 1921-22 when the flock was reduced to 46 birds in September (1922) by the sale of a part of the flock. The average for the 46 birds retained is, as nearly as can be determined, approximately the same as for the entire flock in that year, hence their records are included. The records used include only those for birds that lived up to October 31st of the year after they were hatched.

The birds were kept in units of about 100 birds, in houses having a floor area of 20 x 20 ft. The house has an opening in front 3 x 12 feet, which is covered with wire netting, but was never covered with a curtain. In this connection it may be stated that the mean temperature for the years 1920-26 varied from 48.3°F. to 52.2°F., with a total range of from 9°F. to 92.4°F. The precipitation, which comes mostly in the fall and winter months, averaged 56.13 inches during the past 21 years.

Rations fed and methods of feeding are outlined elsewhere (see B.C. D.A. Bull. No. 93, by Lloyd and Asmundson, 1925). No artificial illumination was used.

Complete trapnest records are kept for all birds. The present paper deals, however, only with such eggs as were laid from November 1st to October 31st inclusive. Unless the time of hatching and other factors are considered, it does not seem worth while to consider eggs laid outside of this period. The period for which records are here used also coincides with most contest years, thereby facilitating comparison with records from other sources. Only such eggs as were laid in trapnests are included in the records reported in this paper. Eggs laid outside of trapnests numbered approximately 1.1 eggs per bird.

The constants (mean, standard deviation, and coefficient of variation) were calculated by the usual formulae. It was deemed advisable to group the records for monthly egg production by one-egg classes, so as to give the correct value to zero records. Annual production was calculated from grouped data, using a class range of 15 eggs (0-14 etc). The range in

monthly egg production was from 0 to 31, the range in annual production from 22 to 306 eggs. All computations were checked, to eliminate errors as far as possible.

Annual Egg Production

The data for annual egg production are shown in Table 1. The mean production increased from 169.981 ± 2.702 to 209.128 ± 3.079 eggs, an increase of 39.147 ± 4.096. This represents a decidedly significant change in the annual egg production. It will be noted that the increases in mean occurred mainly in two years, 1922-23 and 1925-26, although slight increases were secured each year. The mean for 1925-26 as compared with that for 1924-25 probably represents a real gain, although it is not to be expected that the mean would show such a consistent increase in subsequent years.

Table 1. *Summary of Variation Constants for Annual Egg Production*

Year	No of Birds	Mean	Standard Deviation	Coefficient of Variation
1920-21	104	169.981 ± 2.702	40.871 ± 1.913	24.044 ± 1.188
1921-22	46	174.283 ± 3.693	37.136 ± 2.611	21.308 ± 1.565
1922-23	75	191.200 ± 3.296	42.324 ± 2.331	22.136 ± 1.277
1923-24	92	196.294 ± 2.702	38.424 ± 1.910	19.575 ± 1.010
1924-25	92	198.087 ± 3.317	47.169 ± 2.345	23.812 ± 1.249
1925-26	101	209.128 ± 3.079	45.888 ± 2.180	21.943 ± 1.091
All Years	510	191.059 ± 1.340	44.811 ± .946	23.454 ± .522

The variability as shown by the standard deviation has not changed significantly. None of the differences is three times as great as the probable errors of the difference, hence can scarcely be considered significant. If anything, there has been an increase in variability. It is interesting in this connection to note that while the mean annual egg production for this flock of Rhode Island Reds is over 30 eggs greater than that reported by Dunn (1924) for birds in the Storrs Contest, the variability as measured by the standard deviation is practically the same. As a result, the coefficient of variation is considerably lower, or the relative variability is less, for our birds. The coefficient of variation for our birds varies from year to year, but does not show any definite trend.

The mean production (191.05 ± 1.340 eggs) of the birds discussed in this paper is higher than that reported by Dunn (1924) for Rhode Island Reds in the Storrs Contest and other contests. It therefore seemed desirable to compare our records with those made in Canadian contests, and particularly British Columbia contests. Information secured from reports by Elford and Taylor (1924, 1925) for the first five Annual Canadian National contests, and from unpublished reports for two subsequent British Columbia contests, are given in Table 2. There were ten birds in each pen, and only the records of birds that finished the year were considered.

Table 2. *Annual Egg-Production of Rhode Island Reds in Canadian Contests*

Source	No. of Birds	Mean	Standard Deviation	Coefficient of Variation
All Contests, 1919-20 to 1923-24	863	126.13 ± 1.09	47.36 ± .77	37.54 ± .98
B. C. Contests only, 1919-20 to 1923-24	82	178.95 ± 2.80	37.49 ± 1.97	20.95 ± 1.63
B. C. Contests only, 1919-20 to 1925-26	150	195.70 ± 2.52	45.77 ± 1.78	23.39 ± .96

The egg production reported for all Rhode Island Reds entered in the first five Canadian contests was considerably below that shown for birds of the same breed at the University of British Columbia. Only 82 of the 863 records completed in the first five contests were made in British Columbia contests. The mean for these 82 birds is significantly greater than that for the entire group, and hence is more nearly comparable to that for the birds reported in this paper. If the figures for birds entered in the last two British Columbia (Canadian) contests at Agassiz and Sidney are considered, the mean is still further increased, and in fact slightly exceeds the mean reported for the flock studied in this paper. The standard deviation and coefficient of variation in the egg production of birds entered in Canadian contests in British Columbia are similar to the constants reported in Table 1. The relative variability of egg production, as expressed by the coefficient of variation, is much greater for all Rhode Island Reds in the first five Canadian contests than for Rhode Island Reds in British Columbia (Tables 1 and 2). This greater variability is probably due to at least two factors, namely, greater diversity in climate, and greater differences in the inherent qualities of the birds. Climatic conditions vary greatly in different parts of Canada, and a similar variability is indicated in the inherent qualities of the birds entered, by the marked disparity in the performance of different pens in the same contest.

Since the data for birds in British Columbia (Canadian) contests are similar to the data reported in Table 1, it seems reasonable to assume that our data may be used to represent well-bred birds in this Province.

Proportion of High Producers

As noted before, the increase in annual egg production is quite marked. With this increase in egg production (mean) there has been a marked increase in the proportion of high and (comparatively) low producers. The per cent of all birds in the different groups in each year is shown in Table 3. Dunn (1924) classified all birds that laid 210 eggs or over as high producers, and as low producers all those laying 104 eggs or less. Only 2.9 per cent of the Rhode Island Reds at the University of British Columbia laid 104 eggs or less, whilst 36.7 per cent laid 210 eggs or more. Since the number of birds laying less than 105 eggs was insignificant, a different classification was adopted, which seemed better fitted to the data herein reported. The grouping adopted (149 eggs or less, 150 to 224 eggs, and 225 eggs or over) corresponds, so far as numbers go, to that used in Canadian Record of Performance (see reports 1 to 7, issued by the Dominion Live Stock Branch, Ottawa).

Table 3. *Relative Frequency of Hens in Different Fecundity Classes*

Year	Percent Laying 149 eggs and less	Percent Laying 150 to 224 eggs	Percent Laying 225 eggs and more
1920-21	30.8	61.5	7.7
1921-22	23.9	69.6	6.5
1922-23	17.3	58.7	24.0
1923-24	13.0	63.0	23.9
1924-25	15.2	59.8	25.0
1925-26	8.9	50.5	40.6
All Years	17.8	59.6	22.5

Table 3 shows that there was a marked increase in the proportion of birds laying 225 or more eggs. The proportion of such birds decreased slightly in the second year, but increased markedly in the third year (1922-23) and then remained fairly constant for three years, when in the last year there was another considerable increase in these higher producing hens. The two increases of any importance in the proportion of "high" producers coincide with the two greatest increases in mean egg production (Table 1). The changes in the per cent of higher producing birds is further illustrated in Figure 1. The equation for this group of birds is: $y = 5.576 + 6.283 X$, the straight line showing a sharp rise during the six years.

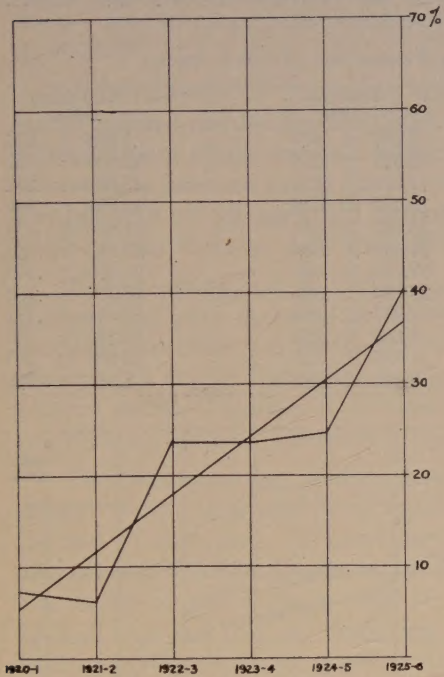

FIGURE 1

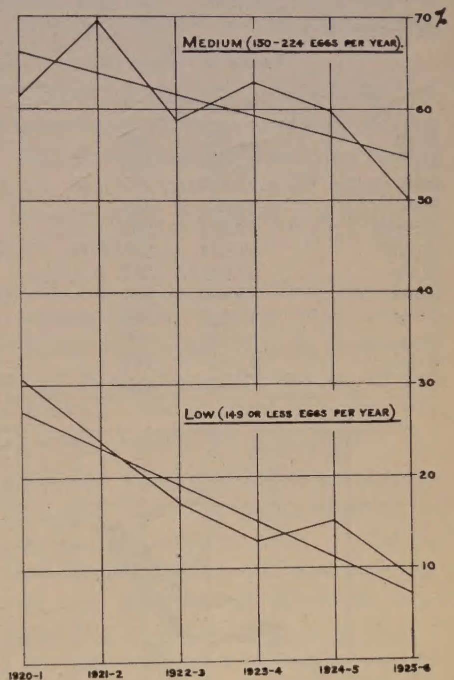

FIGURE 2

FIGURE 1. Annual changes in the percentage of pullets laying 225 or more eggs in their first year. (Charts drawn by Mr. G. Sinclair Smith).

FIGURE 2. Annual changes in the percentage of pullets laying 150 to 224 eggs and pullets laying 149 or fewer eggs.

The equation for the group laying from 150 to 224 eggs is $y = 66.243 - 2.289 X$. There has been a slight decrease in the per cent of birds in this group, as is shown by the upper lines in Figure 2. The per cent of birds with such records has fluctuated somewhat, as indicated in Table 3. The per cent of the entire flock laying 150 to 224 eggs may be expected to vary from year to year, according to the average egg production for the flock and the proportion of high and low producers.

The per cent of the total flock laying 149 eggs or less has decreased steadily, except from 1923-24 to 1924-25. The decrease in the proportion laying less than 150 eggs is shown graphically in Figure 2. The equation

calculated from Table III is $y = 27.224 - 3.997$ X. There has been a marked decrease in the proportion of birds laying 149 or fewer eggs, which has been more than matched by the increase in number of birds laying 225 or more eggs.

Distribution of Egg Production by Months

The data so far presented show that annual egg production has increased, through a change in the proportion of high and low producers. We may now consider the egg production by months. The data for the entire flock, and for the birds hatched in 1920 and 1925, the first and last years respectively, are given in Table 4. The distribution of the monthly means is also shown in Figure 3.

Table 4. *Mean Monthly Egg Production—S.C.R.I. Reds*

	Hatched 1920	Hatched 1925	All Years 1920-25
Nov.	7.952 ± .489	6.267 ± .427	7.306 ± .235
Dec.	12.029 ± .523	13.921 ± .558	12.939 ± .252
Jan.	12.058 ± .467	17.376 ± .526	15.633 ± .232
Feb.	10.067 ± .429	18.030 ± .330	15.394 ± .204
March	19.885 ± .295	23.485 ± .311	21.876 ± .135
April	21.654 ± .248	24.069 ± .330	22.563 ± .128
May	21.231 ± .281	22.713 ± .356	21.326 ± .145
June	15.885 ± .297	20.099 ± .380	18.196 ± .158
July	17.433 ± .332	19.257 ± .394	17.614 ± .171
Aug.	14.500 ± .400	18.564 ± .423	16.243 ± .186
Sept.	11.798 ± .453	15.693 ± .515	13.857 ± .215
Oct.	5.308 ± .439	10.010 ± .539	8.186 ± .225

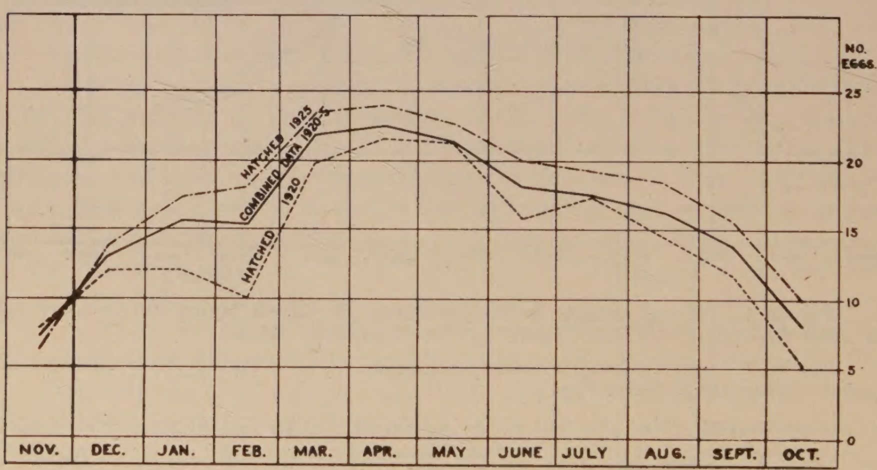

Figure 3. Average monthly egg production in the first laying year.

If the year is divided into seasons it is found that there is a marked increase in the number of eggs laid in each period, but if the proportion of the total eggs laid in each season is calculated it is found that there is little change in the per cent of all eggs laid in any period during the six years. Thus, the number of eggs laid during the first four months (the winter period) increased from 42.1 eggs in 1920-21 to 55.4 eggs in 1925-26, which represented 24.8 and 26.5 per cent respectively of the total. The increase

in the number of eggs laid is therefore, comparatively speaking, greater than the increase in the proportion of the total eggs laid in this period.

For the months of March, April and May, the number laid increased from 62.8 eggs in 1920-21 to 70.3 eggs in 1925-26. This represented a slight decrease in the per cent of all eggs laid during the twelve months, from 37.0 to 33.6 per cent for this period. The egg production increased similarly in the three subsequent months, but the proportion in per cent of all eggs laid remained practically the same. The months of June, July and August were designated "Summer months" by Pearl and Surface (1911). The number of eggs laid in these months increased from 47.8 eggs to 57.9 eggs, but the per cent of all eggs laid in these months was slightly less in 1925-26 than in 1920-21.

The two months of September and October are usually grouped together, but as pointed out by Dunn (1924) September may more correctly be considered a part of the summer period. Egg production in these two months increased to such an extent during the six years (from 17 to 25 eggs) that the per cent of all eggs laid during these months increased 2.2 per cent. Most of this increase is in the month of October.

If egg production in 1920-21 and 1925-26 may be taken to show the changes that have occurred in the egg production by months, then we may conclude that there was no increase in the number of eggs laid in November, and little if any in December, but that egg production increased in all subsequent months (January to October inclusive). The greatest increases were recorded in January, February, June, August, September and October.

The decrease in egg production in February, 1921, may indicate a separate winter "cycle", separated by a "pause" or molt, from the egg production for the rest of the year. This tendency on the part of some birds to "pause" or molt was noted by Goodale (1918) and Hayes (1924). It was no longer discernible in our flock in 1925-26, and was actually not noticeable after 1920-21. A low rate of production during the winter months is, at least in most cases, due to a large proportion of the flock molting after a comparatively short period of laying.

The curve for monthly egg production of all birds, shown by the solid line in Figure 3, is quite regular, rising from the lowest point in November to the peak in April, and then gradually declining to October. This appears to be typical for Rhode Island Reds, since Dunn noted a similar regularity in distribution. The rate of production in the case of the University of B. C. birds was higher than that reported by Dunn in each of the twelve months except October. The peak of production also came in April instead of in March, but the differences in the number of eggs laid in March, April and May are very slight in either case.

Variability in Monthly Egg Production

The absolute variability, or standard deviation (Table 5) in monthly egg production is greatest in December, followed by November, January and October. Our Rhode Island Reds therefore differ from the Leghorns in

that the standard deviation is highest in December rather than in November (Asmundson, 1927) and thus resemble Rhode Island Reds elsewhere. This difference in standard deviation is undoubtedly due to differences in age at first egg, for as with Leghorns, the standard deviation is greatest when egg production is increasing, and least when egg production has reached the highest point for the year. Thus the standard deviation is less for November when egg production has just started, than for December when the rate of egg production is increasing and more birds are laying. The standard deviation is again less for January and February, is least in March, April and May, and again increases as egg production decreases in subsequent months.

TABLE 5. *Standard Deviation of the Mean Monthly Egg Production S.C.R.I. Reds*

	Hatched 1920	Hatched 1925	All Years 1920-25
Nov.	7.396 ± .346	6.357 ± .302	7.862 ± .166
Dec.	7.910 ± .370	8.319 ± .395	8.421 ± .178
Jan.	7.060 ± .330	7.835 ± .372	7.769 ± .164
Feb.	6.493 ± .304	4.920 ± .234	6.822 ± .144
March	4.466 ± .209	4.634 ± .220	4.513 ± .095
April	3.749 ± .175	4.916 ± .234	4.286 ± .090
May	4.245 ± .199	5.298 ± .252	4.847 ± .102
June	4.486 ± .210	5.656 ± .269	5.289 ± .112
July	5.023 ± .235	5.874 ± .279	5.731 ± .121
August	6.054 ± .283	6.302 ± .299	6.207 ± .131
Sept.	6.858 ± .321	7.676 ± .365	7.191 ± .152
Oct.	6.633 ± .310	8.034 ± .382	7.524 ± .159

If the standard deviations in monthly mean egg production for 1920-21 are compared with those for 1925-26 (Table 5) it will be noted that there was an increase in each month except November and February. November was the only month in which egg production showed any tendency to decrease, whilst egg production increased markedly in February. The somewhat higher standard deviation (greater variability) for April and subsequent months appears to be associated with increased egg production during the winter months, more particularly January and February, in this case.

COEFFICIENT OF VARIATION

The coefficient of variation for the Rhode Island Reds is in inverse order to mean egg production (Table 6). The coefficient of variation was highest in November, followed by October, December and September, and

TABLE 6. *Monthly Egg Production—Coefficient of Variation S.C. Rhode Island Reds*

	Hatched 1920	Hatched 1925	All Years 1920-25
Nov.	93.008 ± 7.192	101.434 ± 8.425	107.606 ± 4.135
Dec.	65.758 ± 4.203	59.753 ± 3.716	65.077 ± 1.866
Jan.	58.552 ± 3.558	45.089 ± 2.540	49.696 ± 1.282
Feb.	64.496 ± 4.085	27.289 ± 1.389	44.318 ± 1.104
March	22.461 ± 1.103	19.733 ± .973	20.629 ± .453
April	17.312 ± .834	20.423 ± 1.010	18.995 ± .415
May	19.996 ± .973	23.325 ± 1.666	22.727 ± .504
June	28.239 ± 1.423	28.141 ± 1.439	29.065 ± .663
July	28.811 ± 1.456	30.505 ± 1.578	32.538 ± .756
Auust	41.753 ± 2.269	33.945 ± 1.789	38.211 ± .916
Sept.	58.125 ± 3.521	48.915 ± 2.825	51.891 ± 1.358
Oct.	124.975 ±11.878	80.261 ± 5.767	91.912 ± 3.180

was lowest in April. The relative variability is therefore greatest at the beginning and the end of the year. This is apparently characteristic of all distributions of first-year egg production. It is interesting in this connection to compare the coefficients of variation for 1920-21 and 1925-26. In eight of the eleven months in which egg production increased, the relative variability decreased. In the case of the three other months, the coefficient of variation increased slightly. As noted before, egg production decreased slightly in November, whilst the variability (coefficient of variation) increased. It is obvious that the relative magnitudes of the coefficients of variation for the egg production in different months varies from year to year. Nevertheless, the coefficients of variation of monthly egg production for the entire group may be taken as typical for Rhode Island Reds, since the data presented agree in all essential respects with those given by Dunn (1924) for birds entered in the Storrs Contest.

Summary

The following are some of the more important facts ascertained from a study of 510 records of first-year egg production of S. C. Rhode Island Reds:

1. Annual egg production increased by 39.147 $\pm$ 4.096 eggs, or from 169.98 $\pm$ 2.702 eggs in 1920-21 to 209.128 $\pm$ 3.079 eggs in 1925-26.

2. The mean annual egg production of all birds that completed their records during the six years was 191.059 $\pm$ 1.340 eggs. This was found to be comparable to records made by Rhode Island Red pullets entered in official contests in British Columbia, but higher than records made by Rhode Island Reds elsewhere.

3. The proportion of birds laying 225 eggs or over increased from 7.7 to 40.6 per cent, whilst there was a corresponding decrease in the proportion of birds laying less than 150 eggs, from 30.8 to 8.9 per cent.

4. There was a marked increase in the number of eggs laid in each season, but the proportion of eggs laid in any season changed only slightly.

5. The increase of 39.147 $\pm$ 4.096 eggs for the year was spread over eleven months (December to October inclusive), the increase ranging from a little over one (1.482) egg to nearly eight (7.963) eggs. The number of eggs laid in November decreased slightly.

6. Egg production was lowest in November, gradually increased to the highest production in April, and then decreased gradually until October.

7. Variability in annual egg production changed only slightly during the six years.

8. Variability in monthly egg production was least in the spring months (March, April and May), and greatest in the winter and fall at the beginning and end of the year.

University of British Columbia,
Vancouver, B.C.

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SYRUPS FOR THE AUTUMN FEEDING OF BEES

C. F. Patterson*

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Of great interest to the beekeeper is the subject of syrups for the autumn feeding of bees. At some time or other, especially in northern districts, the beekeeper is called upon to make a syrup for feeding his bees in preparation for winter. The practice of removing from the brood-chamber, either late in the summer or early in the autumn, much of the bees' stores and feeding sufficient syrup to meet the needs of the colony during the winter months has been strongly advocated by bee-keeping authorities, and in Canada and in the Northern States at least this is now considered by many beekeepers to be an essential part of good beekeeping. A large percentage of the beekeepers in these parts have adopted this practice and with the increasing popularity of this method of insuring stores of high quality for winter use, the subject of syrups for autumn feeding becomes of increasing importance.

Probably the greatest problem presenting itself in the autumn feeding of bees is that of obtaining a suitable syrup. Very frequently, the sugar in the syrup fed crystallizes in the combs and if much crystallization takes place, the bees may die from starvation before spring. Many beekeepers make their syrups for autumn feeding merely by dissolving granulated sugar in hot water, and the method recommended in many bulletins on beekeeping consists in bringing the water to the boiling point, removing it from the fire, and then adding the sugar. The failure of the sugar to crystallize out from the syrup made under these conditions, especially if the syrup is thick, may be considered to be a happy stroke of fortune. It has been observed that the addition of honey to a syrup made from water and granulated sugar prevents the crystallization of the sugar in the combs, and some beekeepers have adopted the practice of adding stated amounts of honey to their syrups for fall feeding purposes. The use of tartaric acid in syrup to prevent the crystallization of the sugar has been advocated, and many beekeepers have used it according to the directions supplied. The results obtained from the use of tartaric acid, however, have been inconsistent and have often been disappointing. In some cases, the desired results have been obtained while in other cases crystallization has occurred. Not infrequently do crystals form before the feeders have been emptied and often these crystals close the small openings in the inverted honey-pail where such is being used as a feeder.

During recent years, syrups for the autumn feeding of bees have become a subject of investigation. Willaman (*4*) made a careful study of the possibilities of the use of commercial invertase to prevent the crystallization of sugar in syrups for autumn feeding. His results are very interesting and while the percentages of invert sugar obtained from the use of his methods

* The author acknowledges with pleasure the contributions made by others and especially the contribution made by Dr. T. Thorvaldson, Chief, Department of Chemistry, University of Saskatchewan, and his staff, who made the invert sugar determinations.

are sufficiently high to prevent the crystallization of the sugar under ordinary conditions, the cost of the enzyme and the difficulty of preparation are obstacles to be overcome before the method will meet with favour among beekeepers.

A great step forward in the problem has been made by the United States Bureau of Chemistry (*2*). These investigators have worked out a formula, the use of which results in a heavy syrup from which the sugar will not crystallize readily. Two solutions of granulated sugar in water are required, one more dilute than the other, and to the less concentrated solution tartaric acid is added. The solution containing the tartaric acid is boiled gently for one-half hour, and at the conclusion of the boiling period, the two syrups are mixed for feeding. This syrup seems to be very satisfactory for feeding bees, but the method of manufacture may be objectionable in some cases. The use of a double formula may prove confusing to some beekeepers and the preparation of two solutions, one of which is to be boiled for one-half hour, may involve the expenditure of more labour than the majority of keepers of bees wish to expend on this operation.

It is evident that the beekeeper desires a simple method of preparing syrup for the feeding of his bees for winter. If a simple method is available, many beekeepers will use it in preference to longer and more difficult methods, even though the syrup obtained through the use of a simple method, is inferior and unsatisfactory for autumn feeding. It is highly desirable, therefore, that a short and practicable method of preparing syrup for the fall feeding of bees be devised and that this method be made known to all beekeepers interested in this subject.

With a view to working out a suitable formula to use in the making of syrup for the autumn feeding of bees, the present work was undertaken. Advantage was taken of the information that is available on the inversion of cane-sugar and this served as a basis for the experiments. Considerable progress has been made and it is hoped that the results obtained will aid in simplifying this problem for every keeper of bees interested.

Outline of Experiments.

In all 75 different formulae were used in these experiments. Each lot of syrup was made from two and one-half pounds of sugar and one pound of water. This was found to be a convenient amount to handle, and it proved to be the minimum that could be made to advantage with the equipment available. The resulting solutions were given various treatments.

For convenience the experiments may be divided into two series. In one series are those in which tartaric acid only was added to the sugar solutions, and in the other series are those in which commercial invertase was employed.

In the tartaric acid series of experiments tests were made using tap water, distilled water and rain-water. The tests with tap water and distilled water were numerous, but those with rain-water were few in number and were intended only to demonstrate either the similarity or the dissimilarity between rain-water and distilled water for syrup-making purposes. Two

different amounts of tartaric acid were employed. The smaller amount employed is equivalent to one ounce of tartaric acid to 100 pounds of sugar, or to 140 pounds of syrup made from the proportions of sugar and water mentioned, and the larger amount is equivalent to one ounce of tartaric acid to 50 pounds of sugar or to 70 pounds of such syrup. Two temperatures to which to subject the solutions were chosen, and those selected were 100° C. approximately and 108° C. approximately. The latter proved to be the boiling point of the syrup being subjected to treatment. Seven different periods of exposure were given and these were as follows: 5 minutes, 10 minutes, 15 minutes, 30 minutes, 45 minutes, 60 minutes, and 90 minutes. Various combinations of these different periods of exposure, different temperatures and different amounts of tartaric acid were made. In addition, syrups were made up using the formula recommended by the United States Bureau of Chemistry, and the old standard formulae usually given in bulletins and in text-books on beekeeping.

The experiments in the invertase series were designed after some of those of Willaman and the chief purpose of these was to compare the virtues of invertase and tartaric acid when used in the making of syrups for the autumn feeding of bees. The invertase used was supplied by Wallerstein Laboratories, 171 Madison Avenue, New York City, under the name of "Convertit" and the "K" value of this compound was 0.0012. Four different amounts of "Convertit" were used and these were at the rate of 3 ounces, 6 ounces, 12 ounces and 24 ounces, respectively, to 100 pounds of syrup. One temperature only was employed and the temperature chosen was 60° C. This temperature was believed to be near the upper limit of safety for the enzyme and the use of a higher temperature was avoided. An incubator of standard make provided the desired temperature conditions. The durations of the treatments were 6 hours, 12 hours, 24 hours, 48 hours and 72 hours, respectively. Tap water only was used in the "Invertase" series, and a small amount of tartaric acid, as recommended by Willaman, was used to render the solution acid.

All the lots in the tartaric acid series, with the exception of those exposed 5 minutes and 10 minutes to the temperature used, were made up in November while those treated for 5 minutes and 10 minutes respectively were made up in February. The tap water used in November was very alkaline and had a pH value of 8.2 approximately.

Each lot in each series was sufficiently large to fill three fruit jars of the one-pint size. In the invertase series, the syrup was placed in the jars before the heat treatment was given, and in the tartaric acid series it was placed in the jars soon after the heat treatment was completed, and before the syrup cooled. One jar of each lot was placed in a storage that was maintained at room temperature; another jar of each lot was placed in a storage in which the temperature varied from 34° F. to 38° F. and the third jar of each lot was used for the invert sugar determination. The invert sugar determinations were made by Benedict's method in the Department of Chemistry. Though considered to be accurate only to within two per cent, this method was chosen because of the facility with which the deter-

minations could be made. This degree of accuracy was considered sufficient for these experiments. Invert sugar determinations were not made on the syrups containing neither tartaric acid nor "Convertit" and values for these syrups do not appear in the tables.

Presentation of Data.

For convenience, the results are expressed in tabular form. The values "Percentages of Invert Sugar by Weight" represent the percentages of invert sugar in the solution and not the percentages of the total sugar in the form of invert sugar. In these solutions, the total percentage of sugar varied from 72 per cent to 78 per cent approximately, owing to lack of perfect control over the vaporized water. In every case some moisture escaped in the vapor form and in some cases more was lost than in others. If no moisture had been lost through evaporation, the percentage of sugar present in the solutions in every case would have been 71.4 per cent, approximately. Where the values in the tables are 70 per cent or over, it may be taken that approximately all the sugar present was in the inverted condition.

Table 1 furnishes complete data on the results obtained from the use of tartaric acid with tap water and with distilled water respectively. The table is self-explanatory and the reader can see at a glance the difference obtained between any two of the treatments given.

Where the periods of exposure were short, the amount of tartaric acid used with tap water markedly affected the percentage of invert sugar present in the resulting solutions. The use of the larger amount of tartaric acid greatly increased the percentage of invert sugar and at both temperatures, for the 15 minute period, the percentage of invert sugar present where the larger amount of the chemical was added was more than double that where the smaller amount of the chemical was used. For the longer periods, the differences are less marked. These results are in keeping with expectations as a portion of the tartaric acid added was required to neutralize the strongly alkaline tap water used in the experiments and the solution containing the larger amount of the chemical possessed a much greater degree of acidity than the solution to which the smaller amount of the chemical was added.

The percentages of invert sugar present in syrups made according to a formula in general use and according to the formula supplied by the United States Bureau of Chemistry also may be seen in Table 1. The value for syrup made according to the formula supplied by the United States Bureau of Chemistry is 56.22 and this may be higher than the expected value. The value for syrup made according to the formula in general use is 41.57 and this is doubtless higher than the values for many syrups made according to this formula.

As shown in Table 1 the results obtained from the use of distilled water are unlike those obtained from the use of tap water. It is evident that the resulting solution is more acid where distilled water is used than where tap water is used. Where the exposure to a high temperature was 15 minutes or more, the use of the smaller amount of tartaric acid has given results similar to those obtained from the use of the larger amount of tartaric

acid, and the smaller amount appears to be ample to give the desired results, under these conditions. Even with a 10 minute treatment, the syrup containing the smaller amount of acid tested nearly 60 per cent invert sugar and in a similar syrup with a 15 minute treatment virtually all the sugar present was inverted.

TABLE 1.—*Showing the percentages of invert sugar by weight in syrup solutions made from cane sugar and water in the proportions of two and one-half pounds of sugar to one pound of water under different conditions.*

Kind of Water Used	Amount of Tartaric Acid used per 100 lbs. of Sugar (in ounces)	Temperature °C.	Percentage of Invert Sugar by weight in syrup solutions kept at stated temperatures for 5 Min.	10 Min.	15 Min.	30 Min.	45 Min.	60 Min.	90 Min.
Tap	1	100	—	—	26.76	41.51	68.03	71.99	71.87
Tap	2	100	—	—	54.08	64.83	76.29	73.93	76.59
Tap	1	108	—	—	29.91	60.27	71.51	69.20	76.40
Tap	2	108	—	—	62.12	73.27	77.39	73.82	77.27
Distilled	1	100	52.55	58.39	72.33	69.53	75.11	75.58	74.72
Distilled	2	100	—	—	70.78	73.80	76.68	72.93	76.27
Distilled	1	108	—	—	73.36	73.54	75.38	76.45	77.03
Distilled	2	108	—	—	75.47	75.17	74.84	75.63	74.76
Tap	1½	– made according to old standard formula with no boiling but with solution kept hot for a few minutes—41.57.							
Tap	1	– made according to formula supplied by United States Bureau of Chemistry.—56.22.							

From the values presented in Table 1 it is evident that the higher temperature used in these experiments has only a slight advantage over the lower temperatures used. It is true that in a few cases the higher temperature gave appreciably higher values, but in the majority of cases, the difference is not significant.

Time is evidently a very important factor in the inversion of sugar, and this is brought out in Table 1. When tap water was used an increase in time resulted in an increase in the amount of inversion until the 45 minute period was reached. At the end of this period approximately all the sugar present was inverted and a further increase in time made no appreciable difference to the amount of invert sugar found. When distilled water was used, no increase in the percentage of invert sugar took place beyond the 15 minute exposure and under the conditions of these experiments a 15 minute treatment proved to be sufficient to invert all the sugar present.

At this point it might be stated that the higher temperature had a tendency to render the syrup a light amber colour. In every case the colour of the syrup made at the lower temperature remained unchanged and at the conclusion of the treatment it was water-white. Syrup made with the higher temperature, on the other hand, changed in colour, and after the treatment showed a yellowish tint. In some cases this was very marked, while in other cases it was less marked. The syrup made according to the old standard formula remained uncoloured and the syrup made according to the formula supplied by the United States Bureau of Chemistry was slightly cloudy after treatment.

In Table 2 syrups made under different conditions from the use of distilled water and rain-water respectively are compared with respect to the

amount of invert sugar present. Inversion may be considered to be complete in both cases where a 30 minute exposure was given and in the case of distilled water, it is complete, where an exposure of 15 minutes was allowed. The difference between the 30 minute exposure and the 15 minute exposure for distilled water is due doubtless to a slight difference in conditions beyond the control of the experimenter. The amount of inversion is approximately the same for the two syrups at the 5 minute and the 10 minute exposures but at the 15 minute exposure distilled water yielded 8.5 per cent greater inversion than rain-water.

TABLE 2.—*Comparing syrups made from distilled water and cane sugar with syrups made from rain-water and cane sugar with respect to percentage of invert sugar found present.*

Kind of Water Used	Amount of Tartaric Acid used per 100 lbs. of Sugar (in ozs.)	Temperature °C.	Percentage of Invert Sugar by weight in syrup solutions kept at stated temperatures for 5 Min.	10 Min.	15 Min.	30 Min.
Distilled	1	100	52.55	58.39	72.33	69.53
Rain	1	100	51.15	57.39	63.83	74.88

The results obtained from the use of "Convertit" are given in Table 3. Where the length of treatment was 48 hours or more the amount of "Convertit", within the range used, appears not to be a factor determining the percentage of inversion taking place, as complete inversion was obtained with this period of exposure even when small amounts of the agent were used. For the shorter treatments, the larger amounts of "Convertit" gave higher percentages of invert sugar than the smaller amounts. For complete inversion 12 ounces of "Convertit" were required when the length of treatment was 24 hours and 24 ounces of this agent were required when the treatments were 6 hours and 12 hours respectively.

TABLE 3.—*Showing the percentage invert sugar by weight in syrup solutions made from cane sugar and tap water in the proportions of two and one-half pounds of sugar to one pound of water and to which was added "Convertit."*

Length of treatment (in hours)	Temperature at which solution was maintained °C.	Percentage of Invert Sugar by weight when "Convertit" was used in 100 pounds of syrup in the amounts 3 ounces	6 ounces	12 ounces	24 ounces
6	60	59.65	55.58	69.99	72.52
12	60	60.09	65.03	65.44	70.40
24	60	53.47	61.15	71.05	72.68
48	60	70.55	71.16	73.10	71.56
72	60	70.77	72.83	73.09	72.64

An examination on July 23rd—six months after the syrup from rain-water and those where heating was carried on for 5 minutes and 10 minutes respectively were prepared and eight months after all others included in the test were made—revealed no changes beyond those evident a few days after the syrups were placed in the jars. Some crystallization took place and within 24 hours after being made, the syrup made without the use of either tartaric acid or "Convertit" showed a marked separation of the water and the sugar. At the end of the 24 hour period, the jars, into which these syrups were placed, were at least one-fourth full of crystals, and the fluid was thin and watery. Less than a week later, the syrups made according

to the old formula, where tartaric acid was used but where heating after the chemical is added is not required, showed some separation of the water from the sugar, but this was not as marked as in the former case. These crystals have increased to some extent during the storage period. The remaining syrups, both in the cool storage and in the warm storage are in excellent condition and in no case are visible crystals present. The syrups made according to the formula supplied by the United States Bureau of Chemistry, remain slightly cloudy. Those made according to formulae requiring prolonged boiling have retained their amber tint and those made according to formulae requiring the use of a temperature of 100° C. or 212° F. still exhibit the crystal clearness possessed at the beginning of the test.

Discussion of Results.

From the standpoint of obtaining syrups that show no separation of the sugar from the water under ordinary conditions, even after several months, these experiments have been very successful. If the ability to remain as a thick syrup and to exhibit no separation of the sugar from the water at temperatures above 35° F. were the only essential quality of a syrup for the autumn feeding of bees only two of the formulae used would require discarding. The beekeeper could choose for his use any one of those remaining and could rest assured that no granulation would occur in the combs during the winter months.

The ability to prevent the separation of the sugar from the water under such conditions is not the only desirable quality in a syrup for the autumn feeding of bees. It is well known that syrups used for this purpose must be made from pure cane sugar, must show no evidence of the presence of caramelized sugar, should be of the proper consistency, should be water-white in colour, and should exhibit no sugar crystals at temperatures to which they will be subjected before being consumed by the bees.

Any condition, therefore, that tends to caramelize the sugar present in the syrup should be eliminated. It has been stated that the syrups made from the use of a temperature of 108° C. invariably exhibited a yellowish colour and that the longer the period of exposure, the darker the colour. This colour was doubtless caused by the presence of caramelized sugar formed through the agency of high temperature. The syrups made at a temperature of 100° C. underwent no change in colour and the amounts of caramelized sugar present, if any, in such syrups were very small. Since caramelized sugar in appreciable amounts is undesirable in syrups for the feeding of bees, it becomes necessary to use a temperature below the boiling point of the syrup being made. A temperature of 100° C. has been found to give the desired amount of invert sugar and this may be obtained with a slightly longer exposure than is required where the higher temperature is employed. This longer exposure at the lower temperature has no deleterious effect on the sugar present, and from the information available, it appears safe and prudent in practice to maintain the syrup at a temperature of 100° C. during the inversion period.

Reaction of the water used in making the syrup has been shown to be an important factor in determining the amount of sugar inversion taking

place. Tap waters or well waters are invariably used in practice and since these vary greatly in reaction, the differences in the amount of sugar inversion taking place in the syrups made for feeding are necessarily great. The directions for the use of tartaric acid supplied in literature on beekeeping are usually unqualified and the amount stated is to be used regardless of the reaction of the water. It is obvious that inconsistencies in the results obtained will be experienced while these conditions prevail, especially in districts where some waters are strongly alkaline and where the alkalinity of a given sample varies greatly.

The use of rain water offers a probable solution to this problem. Rain-water closely approaches neutrality and little variation in reaction should be found in uncontaminated samples. The results obtained from it are promising and as compared with the tap water used in these experiments it is markedly superior. The use of rain-water with the smaller amounts of tartaric acid has given a higher percentage of invert sugar than the use of tap water with the larger amounts of tartaric acid. A supply of rain-water is within the reach of every beekeeper and in most cases the sample available would be entirely satisfactory for this purpose. It is true that distilled water is purer than the rain-water found in cisterns and that distilled water could be employed to advantage in making up syrups, but its use is not practicable under average conditions. Rain-water has been found to be almost equal to distilled water for this purpose as measured by the amount of inversion occurring during the treatment and for practical purposes in the preparation of a syrup for feeding bees, clean rain-water may be regarded as a satisfactory substitute for distilled water.

The length of the treatment necessary to give the desired amount of inversion was determined in these experiments by the kind of water, the temperature, and the amount of tartaric acid used. It has already been stated that the use of a temperature of 108° C. resulted in an undesirable syrup, and this temperature may therefore be eliminated from present considerations. Much more tartaric acid is required with tap water than with either rain-water or distilled water to produce a given amount of inversion and since reaction of the water is an important factor in this connection, and since tap waters or well waters both differ and vary greatly with respect to reaction, it appears advisable to consider seriously the discontinuance of the use of these waters in the making of syrups for the autumn feeding of bees. To the average beekeeper, distilled water is not available in large quantities and the use of rain-water must be resorted to. Assuming that the smaller amount of tartaric acid and that a temperature of 100° C. are to be employed, the period of exposure required where rain-water is to be used and where complete inversion is desired is 30 minutes as shown in Table 2. An exposure of 20 minutes under these conditions would invert over 90 per cent of the sugar present and would leave less than 10 per cent in the uninverted condition.

Amount of invert sugar present, however, appears not to be the only factor determining whether or not the sugar will separate from the water in cane-sugar syrup under a given set of conditions. Attention has been directed to the great differences in the amounts of invert sugar present in

the syrups as shown in Table 1 and it has been stated that crystallization has occurred only in the syrup made from the use of tartaric acid, but with the addition of little heat beyond that necessary to bring the water to the boiling point. In this case, the percentage of invert sugar present was 41.57. In two cases where the period of exposure was 15 minutes, the amount of invert sugar present was less than 30 per cent, yet no crystallization occurred even at the low temperature employed in storage.

Doubtless a very important factor in the problem of the crystallization of sugar in syrups for the feeding of bees is completeness of solution. There is evidence that a smaller percentage of invert sugar in the syrup is required to prevent crystallization where solution is complete than where solution is not complete. A syrup as made up for the autumn feeding of bees is a supersaturated solution and the separation of sugar from the solvent is favoured greatly by the presence of a few undissolved sugar crystals. The application of heat for considerable time insures completeness of solution and where syrups are held at a temperature of 100° C. for a few minutes, solution should be complete at the conclusion of the heating period. On the other hand, where the source of heat is withdrawn before the sugar is added to the boiling water or before the large sugar crystals are dissolved, solution may not become complete. The fine undissolved crystals remaining in such a syrup increase in size and soon large crystals may be found on the bottom of the container. Evidently a few small crystals remained undissolved in the syrup made according to the standard formula including tartaric acid, and despite the presence of invert sugar to the extent of 41.57 per cent, some crystallization occurred. In the other two cases referred to and where invert sugar was present in quantities of less than 30 per cent, solution was doubtless complete. Otherwise, some crystallization would have been evident but with solution complete, the syrup contained sufficient invert sugar to prevent the formation of visible crystals under the conditions of storage employed.

Another important factor determining the suitability or non-suitability of a syrup for the autumn feeding of bees is the minimum temperature to which the combs containing the syrup will be subjected during the winter months. It is a well known fact that crystallization in syrups occurs more readily at low temperatures than at high temperatures. Therefore, if the temperature of the atmosphere at any point in the hive where syrup is stored reaches a low level, it is important to have present a syrup that will remain unchanged at that temperature. Stability in the syrup under these conditions may be insured by having solution complete and by having a large percentage of the sugar present in the inverted form. If this temperature remained above the freezing point, a syrup with a lower percentage of invert sugar would be satisfactory provided solution were complete. According to Wilson and Milum (*5*), the temperature of the atmosphere in the hive outside the cluster in outdoor wintering may drop to 15° F. when the temperature of the atmosphere out of doors is -15° F. This was an exceptional instance and where the hive was well insulated under similar atmospheric conditions, the temperature in the hive outside the cluster was 34° F. It must not be overlooked that the temperature in the hive outside the cluster is determined

not only by the outside temperature and the amount of insulation but also by the duration of a given temperature out of doors and by the strength of the colony. In the experiments of Wilson and Milum, the outside temperatures below zero were of short duration and had the outside temperature of -15° F. mentioned above been of long duration, lower temperatures outside the cluster in the hive would doubtless have been recorded. In indoor wintering, it is doubtful that the syrup stored in the combs in any part of the hive reaches a temperature below 40° F. and the expected behaviour of the syrup for which data are given in Tables 1, 2 and 3 would be similar in the combs in an indoor bee storage to that of the syrups in the fruit-jars stored at the low temperature used in these experiments. In the prairie provinces of Canada, where the outdoor temperature occasionally drops to -40° F. and often remains in the vicinity of -30° F. for weeks at a time, the temperature in parts of the hive outside the cluster where bees are being wintered out of doors and where heavy insulation is being employed doubtless reaches a point several degrees below the freezing point. It is possible that this temperature at times approaches 10° F. even where heavy insulation is employed and in the coldest beekeeping districts of North America it would be advisable to provide for this extreme at least when feeding bees for outdoor wintering.

To meet this condition, a syrup from which the sugar will crystallize only with great difficulty should be employed. The first essential is a syrup in which solution is complete. The second essential is a syrup with a high percentage of its sugar in the inverted condition. The natural food of bees is honey and if a syrup containing inverted sugar in the amount of that found in honey were used in feeding bees in the autumn it is probable that favourable results would be obtained. According to Caillas (*3*), honeys differ with respect to the relative amounts of cane-sugar and invert sugar present but in the majority of cases in French honeys, the amount of the total sugar present in the form of cane-sugar is less than 10 per cent. American honeys are reported to contain less cane-sugar and according to Brown (*1*), the average amount occurring in a large group of samples was less than 5 per cent of the total sugar present. It is true that in some honeys this value has been found to be considerably less than 5 per cent but a syrup containing 95 per cent or more of its sugar in the inverted form would not be unlike many samples of honey with respect to the sugar present and would remain unchanged under the conditions prevailing in the hive. Complete solution can be obtained by holding the syrup at a temperature of 100° C. for a few minutes after all plainly visible crystals have been dissolved, and 95 per cent inversion may be obtained by using clean rain-water, adding a small amount of tartaric acid and maintaining the syrup at this temperature for a period of 20 to 25 minutes. The treatment required to produce sugar inversion to the extent of 95 per cent is ample to insure complete solution and further treatment is unnecessary. A syrup thus prepared should possess the qualities desired in a syrup for the autumn feeding of bees, and should meet the requirements of the most exacting beekeeper.

Even though a syrup made according to the suggestions given should furnish a desirable food for the use of bees during the winter months, bee-

keepers are advised not to adopt its use on a large scale until after feeding tests have been conducted. It has already been pointed out that the work here reported was conducted in the laboratory and while the writer is of the opinion that no ill results will follow the use of such a syrup, practical feeding tests are necessary to establish its value in beekeeping. Experimental stations and beekeepers that can afford to carry on experimental work are urged to make up a syrup according to the suggestions given and to use this syrup in feeding a portion of their colonies in the autumn of 1927. Reports made in the spring of 1928 would probably be sufficient to indicate the value of a syrup made according to this formula for the autumn feeding of bees.

Summary.

1. Syrups were made up using various formulae. Sugar was used in every case in the proportion of two and one-half pounds to one pound of water and tap, distilled and rain-waters were compared as constituents of syrups. A portion of the resulting syrup in each instance was placed in a cool storage at a temperature between 34° F. and 38° F., another portion was stored at room temperature and a third portion was used in making sugar determinations.

2. Invert sugar determinations were made on all the syrups prepared and the various syrups were compared with respect to invert sugar present.

3. After being stored eight months the syrups were examined and any physical changes that had taken place were noted.

4. The use of a temperature at the boiling point of the syrups made, or 108° C. approximately, for a few minutes resulted in a yellowing of the syrup and the longer the period of boiling the greater the amount of discolouration.

5. The use of a temperature of 100° C. had no ill effects upon the colour of the syrup and the syrup at the end of the heating period possessed its original clearness.

6. A given amount of tartaric acid was found to be more effective when either distilled water or rain-water was used than when tap water was used. For a given amount of inversion, where the heating periods were short, the former required only one-half the amount of tartaric acid required by the latter.

7. Distilled water was found to be slightly superior to rain-water as measured by the amount of inversion taking place during treatment but for practical purposes in the preparation of syrup for the feeding of bees clean rain-water may be considered a satisfactory substitute for distilled water.

8. From the use of rain-water and tartaric acid at the rate of one ounce of the chemical to 100 pounds of sugar more than 95 per cent inversion may be obtained by holding the syrup at a temperature of 100° C. for a period of 25 minutes.

9. The formula recommended for trial is as follows: rain-water, 40 pounds; granulated sugar, 100 lbs; tartaric acid crystals, one ounce. Main-

tain the syrup at a temperature of 100°C. or 212°F. for 20 to 25 minutes after all visible crystals have been dissolved.

10. Beekeepers are advised not to use this formula extensively until after feeding tests have been conducted and those conducting experimental work in beekeeping are urged to give this formula a trial and are invited to report their results to the author.

UNIVERSITY OF SASKATCHEWAN,
SASKATOON, SASK.

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WHENCE COME THE ROGUES IN CANNING PEAS?*†

R. A. Brink

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The production of a high grade pea pack is first and foremost a matter of growing a uniform crop of a superior variety. Quality does not originate in some skillfully executed canning operation; it must characterize the peas delivered at the factory door. Efforts to improve quality, therefore, must be directed to the pea crop itself. Our attention focuses upon the seed. In regard to kind we shall expect to harvest what we sow; producing the crop is essentially a matter of increase. The character of the seed consequently is a primary consideration.

Twenty years ago geneticists would have outlined a procedure for the development and maintenance of a pure stock of such a self-fertilized crop as peas with a considerable measure of confidence in the infallibility of their scheme. Students of heredity at that time forecasted an era of plant improvement in which a knowledge of the recently established laws of heredity would serve to guide the breeder directly and easily to his goal. Johannsen's work was to the fore, and it seemed sufficient. The Danish investigator's experiments rested upon the solid foundation which Mendel had built and which others had broadened. The problems of selection had been sharply conceived and the methods employed for their solution were exact to a degree not common in the biology of the day. Johannsen's results were illuminating and compelling in their weight. The fundamental implications of his conclusions for evolutionary theory and plant breeding alike were quickly recognized.

We may summarize Johannsen's major contributions as follows:

1. He distinguished clearly between variations having a germinal basis and modifications occasioned by circumstances of the environment.

2. He formulated the genotype hypothesis according to which the breeding potentialities of an individual are determined exclusively by the nuclear organization with which it has been endowed and not by the character of its development.

3. He advanced the pure line theory to account for the non-effect of selection in changing the type of races within perpetually self-fertilized species.

Selection had been a vexed question. Johannsen's work cleared the air. It was a masterly stroke which served to bring in order a perplexing array of facts and to lay a foundation for rational procedure in practice.

The pure line doctrine particularly has found wide application in plant breeding. We might say that it is the corner-stone of plant improvement

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schemes. Mendel showed that continued self-fertilization leads to homozygosis and Johannsen brought forth objective evidence that in forms continuously self-pollinated a homogeneous, true-breeding stock may be obtained by segregating the descendants of a single individual. Autogamous species are collections of pure lines. The plant breeder has taken advantage of this fact in establishing uniform strains by single plant selection in a variety of crops including peas.

Experience amply confirms the idea that the offspring of a single plant regularly reproducing by self-pollination show a high degree of conformity to a type. It was Johannsen's service to show that this arises from the fact that such a group of individuals comprises but a single homozygous genotype. Uniformity is dependent upon the maintenance of this genetic identity. Now plant breeders do find from time to time within pure line varieties aberrant individuals which breed differently from type plants. These are designated in common parlance as "rogues" or "off-types".

The fact that rogues occur does not invalidate Johannsen's conclusions regarding the existence and properties of pure lines. Johannsen himself recognized that a reservation must be made on account of mutations in such stocks. It is the relative importance of these exceptional cases which is to engage our attention. The main doctrine stands today as Johannsen formulated it. However, we may have made insufficient allowance for germinal changes which are known to occur. Perhaps we have gone too far in assuming that heritable changes in pure lines are too infrequent to be of consequence in plant breeding. Barring artificial mixture do pure lines remain sufficiently constant to make periodic reselection unnecessary? This is the problem which forces itself upon our attention in connection with the present situation in canning peas.

Broadly speaking there are two ways in which impurity in a seed stock may arise, namely, through mixing with another stock, and secondly, as a result of genetic changes within the line itself. I do not propose to discuss the first mentioned source of variability in detail. Undoubtedly stray seeds and volunteer plants are a frequent source of atypical individuals. There is nothing obscure about the matter, however, and the means of control are known if not always diligently observed.

Cross pollination with other varieties has been frequently suspected as a cause of variability in pure lines. Definite evidence has been brought forward showing that crossing does occur with sufficient frequency in certain ordinarily self-fertilized crops to necessitate special measures being taken to avoid it. Peas, however, do not appear to fall in this category. Brotherton (*5*) observed but one case of cross pollination by insects among thousands of Gradus plants. Among Gradus rogues, on the other hand, 2.3 per cent of outcrossing was detected in 1919 and 1.2 per cent in 1920. The true amount of cross-pollination in these stocks, is, however, somewhat larger since *inter se* crosses could not be detected. Bateson and Pellew (*2*) remark that cross pollination in the pea is "Excessively rare". In several years' experience they noted but three undoubted cases. White* finds that

* Private communication.

under Long Island conditions natural crossing is so very infrequent that protection against it is not necessary. From the data at hand, it does not appear probable, therefore, that cross-pollination plays an important rôle in destroying the uniformity of strains of peas. Further tests with canning varieties, however, are desirable. If, under certain environmental conditions, crossing should prove to be a source of variation, isolation is the remedy.

We shall concern ourselves particularly with the importance for the breeder of spontaneous genetic changes or mutations. This is an obscure subject. Beyond the fact that mutations occasionally occur and that they may affect various parts of the organism, we know little about them. Provisionally two categories of mutations are recognized; first, those due to the alteration of one gene, the so-called point mutations, and secondly, changes involving a greater portion of the hereditary materials, sometimes the entire chromosome complement. The latter class obviously includes a number of different things which will be further classified when it becomes profitable to do so. Even in the first group we may be placing unrelated phenomena.

Our knowledge of the rate of mutation is likewise meager. In general the changes occur so rarely that their frequency is not easily measured. So far as I am aware, we have numerical data in but two forms, the fruit fly (Drosophila) and the snapdragon (Antirrhinum).

Muller and Altenburg (*7*) have measured the rate of sex-linked lethal mutations in Drosophila. Such germinal changes can be readily detected since the sex ratio among the offspring of a female carrying a recessive sex-linked lethal gene is two females to one male. One-half the sons receive the lethal factor and these die. A total of 1,062 female fruit flies, the offspring of individuals known to be free from sex-linked lethal factors, were tested. Of these 1,062 females, Muller and Altenburg found 20 segregating for sex-linked lethals. This is a frequency of 1 in 53. A similar investigation by Muller on a 3-chromosome stock showed a mutation rate of 1 in 160.

The Drosophila lethal mutations appear to be more frequent than those having effects of less consequence to the organism. In self-fertilized plants lethal factors are of little consequence to the breeder, since they are speedily eliminated from the stock.

Outside of certain studies on variegation in maize, the only investigations on rate of mutation in plants appear to be those of Baur (*4*) on the common snapdragon, *Antirrhinum majus*. During the 18 year period, 1906-1924, Baur maintained a constantly self-fertilized strain, descended from a single plant, A_2, for the particular purpose of determining the frequency of germinal changes. Since most gene mutations are recessive, and are consequently obscured in the presence of their normal allelomorph, it is necessary to breed the offspring of an individual exhaustively in order to determine if a new factor has arisen in the parent plant. Among the descendants of A_2 Baur subjected 344 plants to this two-generation test and detected 16 different mutations. Some of these occurred more than once. Reckoning each mutant but once, however, he found a mutation frequency of nearly 5 per cent.

Baur emphasizes the fact that 5 per cent is a minimum value for rate of mutation in this line. Up until the year 1922 he concerned himself only

with the easily recognizable mutants. Besides these he is of the opinion that there occurs at least an equal number of "small mutations" differing so little from the type that they ordinarily escape detection. In order to increase the chances of recognizing small mutations, large numbers of plants are self-pollinated and the progenies grown in blocks under closely comparable conditions. The groups of plants are then examined. Differences so minute as to be overlooked in a single individual may be discerned if exhibited *en masse*.

The so-called small mutations in Antirrhinum concern all possible morphological and physiological characters. They do not produce monstrosities, but effect changes which still remain within the range of the normal. Viability is not decreased; it may even be increased. Small mutations which have been observed condition, for example, a somewhat darker colour of leaf, a small increase in rate of development, an earlier or a later flowering habit, a slight change in the thickness of the pubescence, and so on.

Baur believes that under the influence of Johannsen's fundamental studies on the constancy of pure lines, we have very greatly overestimated the stability of many forms. We have come to think that gene mutations are always rare and that only abnormalities arise in this way. Baur's *(4)* conclusions regarding the possible significance of small mutations in the snapdragon are so interesting that I venture to quote them in translation as follows:

1. "Small varietal differences continually arise in large numbers under our eyes as factor mutations. For the most part they are so trifling that they are found only by a special experimental procedure. They concern all characters of the plant."

2. "The natural varieties within wild species and closely related wild species themselves are distinguished exclusively by a large number of heritable factors of exactly this sort."

3. "So that it is highly probable that varietal differences and differences between closely related species are simply to be referred to very many factor mutations of this kind, accumulated in the course of time under natural selection, which have proved themselves capable of being preserved or as particularly advantageous."

4. "If a variety, originally genetically uniform, mutates freely in the way depicted—small mutations—and its descendants come under different local and climatic relations, different local varieties and, under [certain] conditions, "species" which are differentiated from each other just as is actually the case in natural races within wild species and in closely related species of Antirrhinum, must eventually arise from it through the summation of mutations by means of natural selection."

5. "This means, consequently, that we come back to the pure Darwinian selection theory, at least with reference to the differentiation of races and closely related species only with the supplement that the original selection material is provided, in the main, through small mutations."

6. "It is self-evident that the selection of particular combinations of mutations must play a large rôle. I do not misapprehend the great importance

of the play of combinations throughout, but, after all, in the last analysis, the mutations provide the original materials for selection."

7. "In striking contrast to this process 'striking' 'large' mutations play a very important rôle in artificial selection. Most of the very striking racial differences in garden varieties of *Antirrhinum majus* are not the sum of small mutations, but go back to only some few, but very productive (ausgiebige) factor mutations. This arises simply from the fact that artificial selection works with a very much coarser sieve than natural selection; in other words, man notices, in general, only the striking mutations and these are mutations which, for the most part, natural selection promptly eliminates."

These conclusions, if sound, are of great interest to the plant breeder. Are small mutations occurring generally among crop plants? Have we, in the past, been attributing small differences in certain classes of individuals wholly to local variations in the environment when, in reality, they rested in part upon a germinal basis? We can not confidently answer these questions at the present time, but the matter has an important bearing on breeding practice.

The impression is current among geneticists that species vary widely in their mutability and Baur finds experimental proof for this in Antirrhinum. The common snapdragon, *Antirrhinum majus,* has produced several mutations as we have seen. *A. siculum,* on the other hand, is highly constant. Another species, *A. orontium* under Baur's observation for three years gave no mutations.

Heritable changes which have a particular interest for us at this time are those responsible for the production of rogues in peas. It has long been known by seedsmen that certain varieties of the edible pea rather frequently throw off-types. The phenomenon has had, however, a relatively small amount of attention at the hands of the scientist. Bateson and Miss Pellew in England have devoted several years' work to the subject and Wilber Brotherton, Jr., in this country has extended their findings. The work at the John Innes Horticultural Institution is still in progress under Miss Pellew's direction.

It should be clearly understood at the outset of our discussion of this subject that the term "rogue" as applied to peas is used in a generic sense. Any plant which does not conform in genetic composition and outward appearance to the variety in which it is found may be designated a rogue. Many different sorts of rogues have been recognized. Certain types occur repeatedly in particular varieties. In Alaska peas, for example, which are grown on a large acreage in Wisconsin, individuals are frequently observed which are later, taller and more productive than type plants. In their habit of growth, these rogues do not conform to any of the commonly grown varieties of peas. Their origin is not certainly known, but it appears highly probable that they are not the result of mechanical mixture. If these particular rogues are due to mutation the germinal change is a progressive one for the proportion of rogues rapidly increases in an unselected stock. Other rogues are earlier than type plants and may account for the "hard peas" occasionally

found in the canned product. Still others show various degrees of floral abnormality and sterility and are probably self-eliminating.

The capacity of certain sorts of rogue peas to perpetuate themselves out of proportion to the varietal type creates a serious problem for the seedsman. In order to produce uniform seed stocks he must frequently rogue his crop in the field. This involves so much labor if well done that the expense of performing the operation is a considerable item in the cost of producing the seed. It is difficult, moreover, to rogue a stock thoroughly; at the time the work is usually done certain kinds of off-types can not be readily seen and are consequently left in the field. As a practical means of maintaining uniform seed stocks, it is admitted that rogueing is only partially satisfactory.

The genetic investigations of Bateson and Miss Pellew and those of Brotherton have been concerned with the so-called "rabbit-eared" rogue. So far as known this rogue does not occur in any American variety of canning peas. The relatively high frequency in which it is produced in the Gradus variety, however, and its curious breeding behaviour makes it especially interesting in connection with studies on variation in the pea. The general appearance of these Gradus rogues is noted as being wild and vetch-like. The foliar parts are narrower than those of type individuals and the pods are upward curving. The plants are vigorous and productive.

Bateson and Pellew (*3*) found that type plants in unselected lines of Early Giant, a strain of the Gradus variety, throw about two per cent of rogues. Different lines vary, however, in their tendency to produce off-types.

The English investigators (*2*) found that Gradus rogues when self-fertilized give only rogues. Reciprocal crosses between types and rogues produce plants which as seedlings show type characters, but as they grow older they become more and more rogue-like until at maturity they can not be distinguished from rogues. The offspring obtained on self-pollinating the F_1 hybrids are exclusively rogues. There are two facts particularly worthy of notice here, first, that F_1 plants are phenotypically types as young seedlings and rogues at maturity, and, secondly, that type plants do not reappear in the second generation.

In explanation of this behaviour Bateson and Pellew (*1*) suggest "that a segregation of factors takes place in the soma, such that the type elements are left behind at the base of the F_1 plant and are thus excluded from the germ lineage".

In addition to pure rogues and types, certain intermediate forms are also found in the Gradus variety. These intermediates are of two kinds, (a) those which throw predominantly types and a few rogues, and (b) those which throw predominantly rogues and a few types. The character of such intermediate plants often changes progressively with growth in the direction of the rogue forms, the lower parts being more type-like and the upper parts more rogue-like. Bateson and Pellew (*1*) definitely established the striking fact that in intermediates throwing mostly rogues and a few types the type individuals are produced only at the lower nodes. This was shown to hold true both on the main stem and on a branch from the base.

Bateson and Pellew (*3*) have found, too, that in intermediates the rogue character is transmitted in different ratios through the pollen and eggs. A further important fact revealed is that samples of pollen taken from different levels of the same plant and applied to types give different proportions of rogues among the offspring. One of Bateson's associates, Miss Thomas, found seven chromosomes in Gradus rogues and types alike, and this fact was confirmed by Matsui (Bateson and Pellew, *3*).

In his studies on hybrids between Gradus type and Gradus rogue Brotherton (*5*) found essentially the same breeding behaviour as Bateson and Pellew describe. Brotherton has gone farther, however, and established the fact that when Gradus rogues are crossed with certain other varieties such as Mummy, both rogues and types are produced in F_2. Mummy is a fasciated variety and is not known to produce rogues. The fasciated condition is recessive. The F_1 of Gradus rogue and Mummy has rogue stipules like the rogue parent. The F_2 showed typical Mendelian segregation for flower color and stem form, and gave 77 per cent rogues; the remaining 23 per cent were intermediates and types. Brotherton further established the fact of segregation in certain F_3 families.

Brotherton (*5*) interprets his findings on the basis of a frequently mutating single factor x present in the Gradus type. It is assumed that the change from type to rogue involves a mutation of x to X. The Mummy variety carries a factor x' allelomorphic to the x of Gradus and differing from it in that it very rarely mutates to X. The heterozygous condition Xx is a very unstable one, x frequently mutating to X. Brotherton calls this phenomenon "mass somatic mutation". He says, further:

"It is probable that the rogues are an extreme manifestation of a series of mutations originating by changes in the x factor of Gradus. Thus the various sorts of intergrading intermediates described by Bateson and Pellew may well represent various modifications of the factor x which may be designated as x'', x''', etc. The xx'' or $x''x''$ combinations produce intergrading intermediates in which mutations of either x or x'' to X is more frequent than in Gradus types. The difference in stability of the various modified x factors, as exhibited in the rate of change of these factors to X, accounts for the existence of high and low rogue-producing strains of intermediates."

Brotherton considers the mutations of x to X comparable to Emerson's (*6*) recurring somatic mutations for pericarp colour in maize and that the varieties of peas in which rogues arise are of the sort described by de Vries as "ever-sporting", that is, it is impossible to eliminate the tendency to produce mutations. The rabbit-eared rogue does appear to have much in common with variegated races of plants among which the case in maize has been most extensively studied. In both, germinal changes are relatively frequent. Emerson (*6*) has shown that variegated maize plants heterozygous for white mutate more often than homozygous individuals. The heterozygous rogue is likewise highly unstable. It has been shown that variegation in maize may be interpreted on the basis of changes at a single locus and Brotherton's work on peas would seem to indicate that in Gradus rogues a similar relation-

ship obtains. In both cases the Mendelian results tend to be obscured by frequent mutations.

Investigation of the rogue situation in peas is just begun. Only one type of rogue has received attention, and the analysis of it might well be carried farther. Some of the things concerning rogues about which we should like to know more are:—

1. What types of rogues occur and how do they differ genetically?
2. What is the relative frequency of rogue production in different varieties?
3. Is it possible by selection to obtain a strain which will not throw rogues from a variety known to have this tendency?
4. Do certain environmental conditions such as an excessive supply of some nutrients cause rogue production or merely serve to reveal the presence of off-types?

The problem of rogues in peas is full of interest from the scientific standpoint, and the breeder would welcome any information which might aid him in circumventing the costly job of annually rogueing the crop.

Department of Genetics,
University of Wisconsin, Madison, Wis.

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A STUDY OF FIELD PLOT TECHNIQUE WITH STRAWBERRIES*

A. N. Wilcox†

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It is apparent from studies in field plot technique made in recent years that greater attention must be devoted to this subject by experimenters who conduct comparative yield tests. Studies have been made with various cereal and vegetable crops and with several tree fruits. It is the purpose of this experiment to study with strawberries the relative value of plots of different sizes and shapes, and of replication.

In most previous studies of field plot technique a given area has been used throughout in comparing the value of plots of different sizes and in determining the value of replication. In actual practice, however, increasing the size of plot or number of replications means increasing the size of the field. It is generally recognized that increasing the size of the field increases the variability as well. In the present study this factor has been taken into account and the value of replication has been correctly determined.

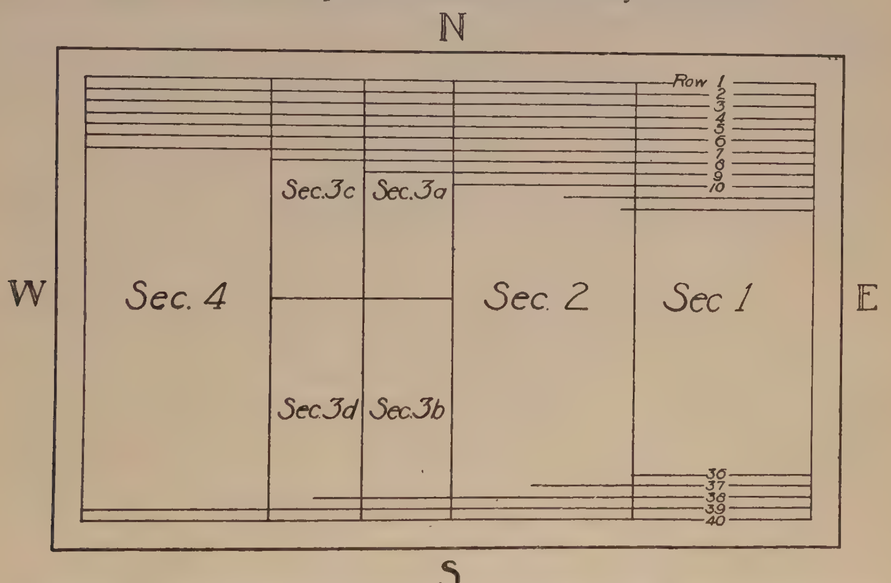

Figure 1. Arrangement of the one-acre field of strawberries, showing rows running east and west and lines dividing the field into sections.

At the Minnesota Fruit Breeding Farm a field of approximately 1 acre, 150 feet by 272 feet, was selected for its suitability for the experiment. The field sloped gently and smoothly to the east and appeared to be comparatively uniform. The entire field was planted to the variety Minnehaha, which is

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† The author is especially indebted to Dr. H. K. Hayes for helpful advice and criticism throughout the experiment.

well suited to Minnesota conditions. Forty rows 4 feet apart, with plants 2 feet apart in the row, were run east and west, lengthwise of the field (See Figure 1). Borders were planted in addition. The field was then divided crosswise into 4 sections, and section 3 was again divided into 4 sub-sections. Thus each full section consisted of 40 rows or plots, each 68 feet long or 1/160 acre in size, and section 3 was further subdivided into single-row plots of 1/320 acre.

The yields of the several pickings of each plot were measured in half pint units and the seasonal yields were converted into quarts per acre for each plot. The yields of contiguous small plots were then combined in various ways to compare the relative value of plots of different sizes and shapes. For example, combining the yields of plot 1 in sections 1, 2, 3, and 4 gave the yield of 1 single-row plot 272 feet long, or 1/40 acre in area. Forty such plots were contained in the field, and the yields of these 40 plots were used for calculating their coefficient of variability.

TABLE 1.—*The relative variability of single-row plots of different sizes, based on 40 trials.*

Area per plot, acres	Length of plot ft.	Section of field	Coefficient of variability	Average C. of V.	Theoret. expected
1/320	34	Sec. 3a; b	16.09 ± 1.24		
"	"	Sec. 3c, d	24.67 ± 1.97	20.4	20.4
1/160	68	Sec. 1	27.79 ± 2.25		
"	"	Sec. 2	15.95 ± 1.23		
"	"	Sec. 3	17.64 ± 1.37		
"	"	Sec. 4	19.24 ± 1.50	20.2	14.4
1/80	136	Sec. 1, 2	17.73 ± 1.38		
"	"	Sec. 3, 4	15.99 ± 1.24	16.9	10.2
1/40	272	Entire	14.12 ± 1.09	14.1	7.2

The results of the experiment are given in the accompanying tables. The coefficient of variability is used throughout as the measure of variability. Table 1 shows the relative variability of single-row plots of different sizes. It is immediately apparent that plots of the same size show much greater variability in some parts of the field than in others. When the average coefficients of variability are considered, however, the larger plots are seen to be less variable than the smaller plots. For comparison with these values the theoretically expected coefficients are shown in the last column. These are calculated on the basis of the smallest size plot used. When the values shown in the last two columns are compared, it is apparent that increasing the size of plot reduces the variability to some extent, but not more than half as rapidly as the theoretical expectation.

Considering the number of plots in this experiment, calculations based on 40 trials permit studying only a small number of replications. Consequently the value of replication was studied on the basis of 20 trials. This is more nearly the number of varieties which a breeder might wish to compare on a large scale for yielding ability. It is furthermore about the smallest number that gives a fairly good random sample.

The yields of systematically distributed plots were used in studying the value of replication. In studying two replications in section 1, for instance, the yields of plots 1 and 21 were combined, the yields of plots 2 and 22, 3 and 23, and so on, so that each trial represented two systematically distributed plots. The yields of the 20 trials were then used for the calculation of the coefficient of variability.

TABLE 2.—*The relative variability of single and of replicated 1/320 acre plots, based on 20 trials.*

Plots per trial	Area under test, acres	Section of field	Coefficient of variability	Average C. of V.	Theoret. expected
1	1/16	3a	16.93 ± 1.86		
1	"	3b	14.77 ± 1.60		
1	"	3c	24.33 ± 2.75		
1	"	3d	22.23 ± 2.49	19.6	
1	1/16	3a, c N½	18.26 ± 2.01		
1	"	3a, c S½	14.66 ± 1.60		
1	"	3b, d N½	12.00 ± 1.29		
1	"	3b, d S½	22.95 ± 2.57	17.0	18.3
2	1/8	3a, b	11.97 ± 1.29		
2	"	3c, d	17.25 ± 1.90	14.6	
2	1/8	3a, c	16.86 ± 1.85		
2	"	3b, d	13.34 ± 1.45	15.1	12.9
4	1/4		10.92 ± 1.18	10.9	9.2

TABLE 3.—*The relative variability of single and of replicated 1/160 acre plots, based on 20 trials.*

Plots per trial	Area under test, acres	Section of field	Coefficient of variability	Average C. of V.	Theoret. expected
1	1/8	1, N½	26.88 ± 3.07		
1	"	1, S½	8.88 ± 0.95		
1	"	2, N½	17.51 ± 1.92		
1	"	2, S½	14.18 ± 1.54		
1	"	3, N½	16.46 ± 1.80		
1	"	3, S½	16.48 ± 1.81		
1	"	4, N½	16.17 ± 1.78		
1	"	4, S½	15.24 ± 1.66	16.5	16.5
2	1/4	1	11.74 ± 1.26		
2	"	2	10.34 ± 1.11		
2	"	3	12.95 ± 1.41		
2	"	4	13.52 ± 1.47	12.1	
2	1/4	1, 2, N½	16.88 ± 1.85		
2	"	1, 2, S½	8.91 ± 0.95		
2	"	3, 4, N½	13.24 ± 1.44		
2	"	3, 4, S½	10.78 ± 1.16	12.5	11.7
4	1/2	1, 2	9.07 ± 0.97		
4	"	3, 4	10.32 ± 1.11	9.7	8.2
8	1	Entire	6.98 ± 0.74	7.0	5.9

The value of using systematically distributed replications of 1/320 acre plots is shown in Table 2, and of 1/160 acre plots in Table 3. In both cases increasing the number of replications considerably reduces the variability. In fact, the actual reduction in variability is not significantly less than the theoretically expected reduction.

TABLE 4.—*The relative variability of 1/40 acre plots of different shapes, based on 40 trials.*

Length of plot, ft.	Width of plot, ft.	Coefficient of variability
272	4	14.12 ± 1.09
136	8	14.05 ± 1.08
68	16	18.27 ± 1.42

A comparison of the relative value of different shapes of plots (Table 4) shows the slight advantage of using a long, narrow plot. This shape is also more convenient to use. The long narrow plot is preferable when the factor of competition between adjacent plots is insignificant.

These results indicate the suitability under these conditions of plots as small as 1/320 acre consisting of single rows 34 feet long, for comparative yield tests with strawberries. Variability may be reduced somewhat, though not in proportion to the theoretical expectation, by increasing the size of the plots. Variability may be reduced more rapidly, however, by repeating the plots in replications distributed systematically over the field. Four to eight replications give a very considerable reduction of variability.

UNIVERSITY FARM,
ST. PAUL, MINN.

PRICE DIFFERENTIALS IN WHEAT BETWEEN MINNEAPOLIS AND WINNIPEG.

JAMES H. BREDIN*

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The analysis of the factors influencing the price differential in wheat between Minneapolis and Winnipeg is of importance in several connections. The producer of spring wheat in the North-Western States would like to know how much he is protected by the tariff on wheat, and the Canadian grain grower wants to know why the price in Winnipeg is frequently much out of line with American prices. It is fundamental to any logical conception of the surplus problem or tariff legislation on wheat, and while it is impossible to obtain an exact measurement of the various influential factors, the relative importance of each may be obtained by statistical methods.

The fluctuation in the price differential in wheat between Minneapolis and Winnipeg, during the last three decades, has been great. The range within one year has been as much as 40 cents per bushel. On March 5th, 1924, the closing price of No. 1 Dark Northern Spring in Minneapolis was 32½ cents higher than No. 1 Northern in Winnipeg, while eight months later the same grade in Winnipeg sold for 8 cents more than did No. 1 Dark Northern Spring in Minneapolis. Various explanations have been offered for these violent oscillations. In a letter to the *Northwestern Miller* on May 6th, 1927, Mr. D. L. Smith, sales manager of the Canadian Co-operative Wheat Producers, states, "In what previous year have we seen the Winnipeg market commanding the premium it is today over the tariff protected markets of the United States?" Dr. A. E. Taylor, of Stanford University, states, "The Canadian crop of 1924 was short, resulting in relative increase in the price of Canadian wheat."† Both of these statements are probably true to some extent. However, Mr. Smith does not explain clearly how the action of the Wheat Pool can increase the price in Winnipeg without increasing the world level by a similar amount, nor does Dr. Taylor explain how a short Canadian crop can lower the price differential while both countries are exporting to a common market.

The most important factors influencing the spread in wheat prices between Minneapolis and Winnipeg are:

(1) The production of Hard Red Spring wheat in the United States.
(2) The percentage of No. 1 Northern of the total wheat crop in Canada.
(3) Production and quality of Hard Red Winter wheat.
(4) The percentage of No. 1 Northern Spring wheat of the total wheat crop in the United States.
(5) The rate of exchange.

* The writer is especially indebted to Dr. H. B. Price, Professor of Agricultural Economics at the University of Minnesota, for valuable criticism and advice.

† Wheat Studies of the Food Research Institute, Stanford University, June 1927.

(6) The tariff.
(7) Transportation costs.
(8) Domestic demand.
(9) The world wheat situation.

Percentage of Number One Northern Wheat in Canada

Next in importance to the production of Hard Red spring wheat in the United States is the quality of the Canadian spring wheat, represented in this study by the percentage that No. 1 Northern is of the total crop in western Canada. On account of early frosts and unfavorable weather, the percentage of Canadian No. 1 Northern wheat ranges very widely between different crops. Since 1910 the range has been from 2.16 per cent in 1911 to 51.90 per cent in 1922. Production in western Canada in 1924-25 was only 236,000,000 bushels, of which only 17 per cent graded No. 1 Northern. Naturally, a small crop, with a small percentage of high grade wheat, will produce keen competition for the high quality wheat, resulting in a premium for No. 1 Northern, and an unusual proportion of low grade wheat causes a discount on the lower grades, making a wide spread between the price of No. 1 Northern and the price at which the bulk of the crop is sold.

The average spread between No. 1 Northern and No. 5 Northern, for example, is about 20 cents per bushel when a normal percentage of the crop is of high quality. The average spread during 1922-23, when 52 per cent of the crop graded No. 1 Northern, was 16 cents per bushel. In 1923-24 was 19 cents per bushel when 32 per cent of the crop graded No. 1 Northern. During 1924-25, when only 17.69 per cent of the wheat graded No. 1 Northern, the spread between this grade and No. 5 Northern averaged 33 cents per bushel, and was as much as 55 cents during the fall months, when huge quantities of low grade wheat were inspected daily. It is clear that the price of No. 1 Northern wheat did not represent the price of the bulk of Canadian wheat in 1924-25, and that the general statement that the price of wheat was higher in Canada than in the United States is not valid. In this particular year the quality of the Canadian crop rather than the short crop or the action of the Wheat Pool was responsible for the relatively high price of the Canadian high grade wheat.

During the years 1921-22, 1922-23, and 1923-24, when the percentage of No. 1 Northern wheat in Canada was high, the spread between Minneapolis and Winnipeg was high, ranging from about 12 to 28 cents per bushel for Manitoba No. 1 Northern and No. 1 Dark Northern Spring. During the year 1924-25, the price at Winnipeg averaged about one cent above No. 1 Dark Northern Spring. In May and June of that year the Winnipeg price was higher than Liverpool by 10 to 15 cents per bushel, a situation which has seldom, if ever, been known except in a very abnormal period, as in the year 1919-20. This supports the theory that the price of Manitoba No. 1 Northern was unduly high on account of the shortage of that grade.

The Rate of Exchange

During the last twenty-five years, the rate of exchange between Canada and the United States has varied from 86.5 in February, 1920, to 100.09 in

October, 1925. When the value of Canadian money is worth, say 95 cents on the dollar, it simply means that if wheat is selling at $1.00 per bushel in Winnipeg an American miller could buy one bushel with 95 cents of the money of his own country. Therefore, the price in Canada would tend to be 5 cents per bushel higher than on the Minneapolis market. To make a fair comparison it is necessary to put the values on a comparable basis either by inflating the American price or deflating the Canadian price. In this study, both the Canadian and English values have been brought to an American basis and thus the effect of the rate of exchange has been eliminated. That is to say, if the actual price paid in Winnipeg was $1.25 per bushel and the rate of exchange was 5 per cent, then the comparable price would be $1.18¾. In the correlation computations made here, conversions have been made into American money at the current rate of exchange, as reported by the Federal Reserve Board since July, 1919. Previous to 1916 the rate of exchange was practically a negligible factor because of the minor fluctuations. The years from 1917 to 1920 have been omitted on account of government price-fixing; thus the rate of exchange has been fairly well provided for. The general price level does not seem to affect the price differential between Winnipeg and Minneapolis appreciably. A higher or lower price level would not in any way prevent a dealer from buying wheat in the lower market. But the differential is affected in so far as the price level affects the costs of transportation. If the freight rates and handling charges between Fort William and Minneapolis are increased on account of a rising price level, the differential between these two markets may be increased by an amount equal to the increase in transportation and handling costs, assuming the Canadian wheat is shipped to Minneapolis. However, such charges, on account of being so small, are unimportant in affecting the Minneapolis-Winnipeg price spreads.

The Rate of Duty

As the rate of duty on wheat changed seven times during the period from 1899 to 1924, it would appear that it should be included as one of the important factors in an analysis of inter-market price spreads. The tariff, undoubtedly, has an influence on the differential when the price of a comparable grade in Fort William is less than the price in Buffalo by an amount greater than the cost of transportation. It is also clear that before Canadian wheat, on which the duty is paid, can be imported by American millers, the price in Fort William must be at least 42 cents per bushel lower than the price in American markets. The importations, since the introduction of the emergency tariff in 1921, have ranged from about 12,000,000 bushels in 1922 to approximately 3,000,000 bushels in 1925. This does not necessarily imply that the tariff was effective to the full amount of the rate while this wheat was actually being imported. The theory that only the higher quality of a commodity can be imported over a tariff wall does not always hold true in the case of wheat. It is obvious that 42 cents per bushel is relatively not as great on wheat costing $1.50 as on a lower grade at $1.25. However, there are certain conditions under which it will pay American millers to purchase the lower priced wheat and pay a relatively greater rate of duty.

For example, when the Canadian drying plants cannot handle all the tough wheat coming on to the market, the price may easily fall to a point where it will be profitable for the American dealer to buy this grade of wheat and pay the duty. In the fall of 1924, the spread between No. 1 Northern Manitoba and No. 5 Northern at Winnipeg was about 50 cents per bushel while the spread between the price of high and low grades in Minneapolis was approximately normal. Under these conditions, low grade Canadian wheat may be imported while the differential between Minneapolis No. 1 Northern and Winnipeg No. 1 Northern is much less than the rate of duty. It therefore appears that the magnitude of the price differential between the high grade does not necessarily control the importations of wheat from Canada. Future prices in both Canada and the United States are based on No. 1 Northern. Therefore, the assumption that the differential between futures must approximate the rate of duty before there are importations from Canada, is not valid.

The tariff is important as a factor affecting market differentials only in so far as it allows other factors to be effective in causing a price differential. When the spread between comparable grades is less than the rate of duty, the tariff is not effective to the full extent. This indicates that when the spread is, say, 30 cents per bushel, a 42 cent tariff would be no more effective than a much higher rate. Furthermore, during the whole period there have been only a few occasions in which the spread appears to have been directly limited by the rate of duty to any great extent. The heavy black line on Chart No. 1 indicates the amount of the tariff during the period included in this study. It will be observed that during the period from 1913 to 1916 when the tariff was only 10 cents per bushel, the price differential, indicated by the heavy dotted line, was low. This chart indicates that, during this period, the price differential was limited by the rate of duty, and therefore it would appear that, during certain periods, the tariff was effective to the full extent. That is, there were occasional periods when the spread would doubtless have been larger if the rate of duty had been higher. Under these circumstances, it is evident that the rate of duty as a variable in a correlation analysis can have very little effect on the final coefficient of correlation. The degree of relationship between the price differential and the rate of duty (r_{16}) was only — .03. The partial coefficient of correlation between the price differential and the production of Hard Red Spring wheat in the United States, holding the tariff constant, was ($r_{12\cdot 6} = -.42$). That is, by holding the tariff constant, r_{12} was raised from — .41 to — .42, showing decidedly that changes in the tariff, during this period, did not have a great effect on the Minneapolis-Winnipeg differential. This supports the contention that the rate of duty is not an important factor in the price of wheat either in Canada or the United States, except in so far as it permits other factors to exert a greater influence.

When comparing the rate of duty with the price differential given in this article it must be remembered that the latter is somewhat too low, as Manitoba No. 1 Northern is worth several cents more than the American No. 1 Northern Spring. This, of course, has no influence on the coefficient

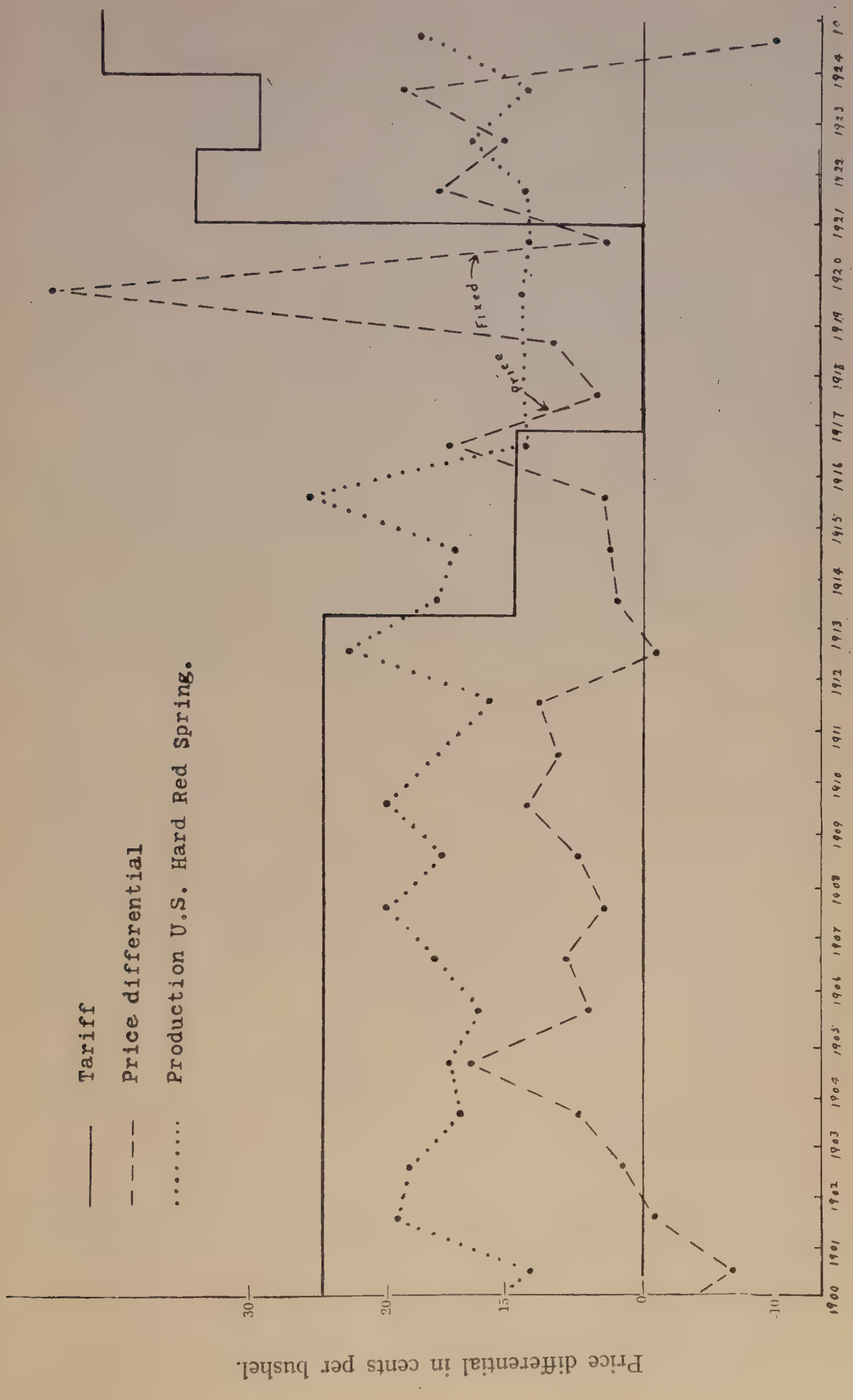
Tariff
Price differential
Production U.S. Hard Red Spring.
Fixed price
Price differential in cents per bushel.
30
20
15
0
-10
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924

Chart 1

obtained in the correlation analysis. The price of No. 1 Northern was used principally because the future prices are based on this grade in both countries. Furthermore, it was impossible to obtain reliable and consistent figures for the quality of wheat comparable with No. 1 Dark Northern Spring for the period from 1899 to 1925. Nor could the average monthly prices be obtained for No. 2 Northern Manitoba previous to 1910.

Where there is a trend involved, it is, of course, necessary to use some method such as first differences or expressing the data as ratios to trend in order that the final results will represent the true relationship between the variables and not merely the relationship between trends. No appreciable growth influence, due to the time element, appears in any of the independent variables used in the correlation analysis. Consequently, the trend element need not be considered in the statistical method here employed.

The production of Hard Red Spring wheat has remained fairly constant with a slight downward tendency during the last five or six years. This decrease, together with the growth in population, is somewhat offset by the decrease in per capita demand. On the other hand, the trend of the percentage of Manitoba No. 1 Northern is slightly upward, as would be expected on account of the introduction of early maturing varieties of wheat. However, these trends are both slight and their influence is negligible, and therefore the method of deviations from the arithmetic mean is used. The price differential, of course, exhibits no trend.

Analysis of Statistical Data

The price differential was obtained by subtracting the monthly average of the Winnipeg daily cash closing price, corrected for the rate of exchange, from the weighted monthly average price of the reported cash sales at Minneapolis*. The average of these monthly differentials was then obtained for the crop year beginning with August. This differential price was used as the dependent variable in a multiple correlation analysis with the following independent variables:

X_2 = Production of Hard Red Spring wheat in North Dakota, South Dakota, Montana, and Minnesota.

X_3 = The percentage of No. 1 Northern Manitoba of the total Hard Red Spring wheat crop in Western Canada.

X_4 = The production of Winter wheat in the United States.

X_5 = The percentage of No. 1 Northern Spring of the total Hard Red Spring wheat crop in the United States.

X_6 = Rate of duty.

* United States Department of Agriculture, Statistical Bulletin No. 12, pages 79 and 83. The Winnipeg price for the years previous to 1909 were obtained from Mr. F. J. Horning, Chief of the Dominion Bureau of Statistics, Ottawa, Canada.

The following results were obtained from the correlation analysis between the price differential and the five independent variables:

$r_{12} = -.408$	$r_{23} = +.321$	$r_{35} = +.008$
$r_{13} = +.182$	$r_{24} = +.042$	$r_{36} = -.081$
$r_{14} = +.152$	$r_{25} = +.271$	$r_{45} = +.244$
$r_{15} = -.222$	$r_{26} = -.182$	$r_{46} = -.156$
$r_{16} = -.028$	$r_{34} = +.545$	$r_{56} = +.242$

COEFFICIENTS OF PARTIAL CORRELATION

$r_{12\cdot3456} = -.476$
$r_{13\cdot2456} = +.434$
$r_{14\cdot2356} = -.031$
$r_{15\cdot2346} = -.339$
$r_{16\cdot2345} = +.012$

COEFFICIENTS OF NET REGRESSION

$b_{12\cdot3456} = -.07802$
$b_{13\cdot2456} = +.27138$
$b_{14\cdot2356} = -.00217$
$b_{15\cdot2346} = -.18186$
$b_{16\cdot2345} = +.00988$
$a = +17.571$

COEFFICIENTS OF MULTIPLE CORRELATION

$R_{1\cdot23456} = .607$

The simple correlation between the dependent variable and one independent variable, for instance r_{12}, simply describes the relationship between these two variables when all other factors are ignored. The net or partial correlation described as $r_{12\cdot3456}$ is a measure of the relationship between the dependent variable and the independent variables when all the other factors are held constant. That is, if one possessed enough data it would be possible to pick out a number of years in which the average value of the independent variables remained unchanged. If a correlation is made for these years the same result is obtained as when the method of partial correlation is used. Concretely, if one had enough data and wished to know what effect the production of Hard Red Spring wheat in the United States had on the price differential when all other factors are held constant, he could pick out the years when all these factors had an average value and correlate the production of Hard Red Spring wheat in these years with the price differential. Obviously, it is impossible to secure many observations when all the independent variables are constant except the one we wish to isolate for study. The method of partial correlation is, therefore, used in securing the net effect of each variable.

The simple correlation between the price differential and the various factors indicates that the production and quality of American Hard Red Spring wheat are the two most important factors influencing the spread. However, when the other factors are held constant the percentage of No. 1 Northern in Canada proves to be almost as important as the production of American Hard Red Spring wheat. The partial coefficient between the price differential and the percentage of No. 1 Northern in Canada ($r_{13\cdot2456}=+.434$) is very much higher than the simple coefficient ($r_{13}=+.182$). This indicates that the percentage of high quality wheat in Canada has considerable influence when the American Hard Red Spring wheat and Hard Red Winter

wheat crops are normal. But, if either of these crops is large or small, the effect of the Canadian factor is obscured.

The equation of regression which describes the relationship between the price differential and the five independent variables is of the form:

$X_1 = a - b_{12 \cdot 3456}\ X_2 + b_{13 \cdot 2456}\ X_3 - b_{14 \cdot 2356}\ X_4 - b_{15 \cdot 2346}\ X_5 + b_{16 \cdot 2345}\ X_6$

Substituting values of (a) and (b):

$X_1 = +\ 17.571 - .0780\ X_2 + .2713\ X_3 - .0021\ X_4 - .1818\ X_5 + .0098\ X_6$

The percentage of No. 1 Northern of the total Hard Red Spring wheat crop in the North Western States is also important. The data show that the variation in this variable ranges from 9 per cent in 1916 to 67 per cent in 1922. There is a fairly high degree of positive correlation between this factor and the corresponding variable in Canada ($r_{35} = +\ .51$). For instance, in 1916 only 9 per cent of the bread-producing spring wheat in each country graded No. 1 Northern. These factors, however, have the opposite effect on the price differential. A low percentage in Canada tends to lower the spread, while a low percentage in the United States tends to increase it. Similarly, in 1922, 42 per cent graded No. 1 Northern in Canada, corresponding to 67 per cent in the United States. In this case the tendency would be for the Canadian crop to increase the spread, and for the American crop to narrow it.

Conclusion

The foregoing study leads to the conclusion that the statistical material tells only a part of the story. It indicates that there are influential factors affecting the price differential which cannot be numerically measured. Perhaps the most important of these is the opinion of the grain dealers. Cash prices are closely connected with future prices, and future prices are greatly influenced by the action of speculators. When large quantities of wheat are sold in one market against purchases in another, the spread is more or less affected. Lack of information regarding economic conditions prevents the public from making logical purchases of futures which would keep the markets properly adjusted.

It is not assumed that a formula can be set up by which price differentials may be forecasted in advance with any degree of accuracy. As stated above, the factors used do not show a high degree of relationship, and besides this, even if a very high coefficient of correlation had been obtained, the use of a formula would require extreme care. Conditions are continually changing. What may hold true for a time series from 1889 to 1925 may not hold true for a period from, say 1891 to 1927. As W. L. Crum says, "The assumption, in case of a time series, that the segment of the series actually analysed can be regarded as a random sample of adjacent or longer segments is exceedingly dangerous."* The results obtained from a formula would, however, give a foundation on which one may base his individual judgment. It is very important that statistical methods applied to any time series, such as this, should be acompanied by a full appreciation of the limitations of such an analysis.

Although it would be extremely dangerous to use the formula, $X_1 = +\ 17.571 - .078\ X_2 + .2713\ X_3 - .0021\ X_4 - .1818\ X_5$, in estimat-

* Journal American Statistical Association June 1925, page 212.

ing future price differentials, the analysis points out the significance and relative importance of the independent variables. For instance, it is fairly evident that the production of Hard Red Spring wheat and the percentage of high quality wheat in Canada are the two most important factors. It is also clear that the production of Hard Red Winter wheat has considerable influence, especially during a season when the American Hard Red Spring wheat crop is unusually small.

The statistical analysis shows that changes in the rate of duty have had very little influence on the Minneapolis-Winnipeg price differentials. This indicates that the tariff has seldom been effective to the full extent and, therefore, the rate of duty on wheat is only of minor importance, except to the American producer of very high quality Hard Red Spring wheat. The tariff has little or no effect when the price of Number One Northern at Fort William is as high or higher than the highest price paid for a comparable grade in Minneapolis. The partial coefficient of correlation between the dependent variable and the percentage of No. 1 Northern of the total American Hard Red Spring wheat crop indicates that the variation in the percentage of high grade Hard Red Spring wheat in the United States is not sufficient to cause any marked effect on the spread. On the other hand, the percentage of high grade wheat in Western Canada has a marked effect, evidently due to the fact that early fall frosts occasionally lower the quality of a large percentage of the crop.

Division of Agricultural Economics,
University of Minnesota, St. Paul, Minn.

Appendix A.

Dependent and independent variables used in correlation analysis.

Year	Differential	Prod. H.R.S. wheat, U.S.A.	Per cent No. 1 Nor. Can.	Winter wheat	Per cent No. 1. Nor. S.	Tariff
	X_1	X_2	X_3	X_4	X_5	X_6
1899-00	–1.0	160	12	292	37	25
1900-01	–7.4	87	0.004	350	23	25
1901-02	–1.0	193	25	458	13	25
1902-03	1.8	188	22	411	24	25
1903-04	4.6	122	13	400	16	25
1904-05	13.4	155	7	332	11	25
1905-06	4.0	193	42	428	27	25
1906-07	6.0	151	30	492	27	25
1907-08	3.0	134	9	409	21	25
1908-09	5.2	159	12	437	35	25
1909-10	9.6	199	25	419	45	25
1910-11	7.5	157	12	434	37	25
1911-12	8.0	121	2	431	13	25
1912-13	–1.8	236	8	400	37	25
1913-14	1.0	165	43	523	51	10
1914-15	1.2	144	13	685	22	10
1915-16	3.0	261	46	674	29	10
1916-17	15.0	94	9	480	09	10
1921-22	18.0	92	25	600	24	35
1922-23	10.8	133	52	587	67	30
1923-24	19.0	91	32	571	25	30
1924-25	–10.3	175	18	589	52	42
Sum	109.6	3410	456	10402	645	527
Average	4.982	155.0	20.72	472.82	29.318	23.9

THE EDUCATIONAL VALUE OF AGRICULTURAL INSTRUCTION IN ELEMENTARY AND SECONDARY SCHOOLS*

J. W. Gibson

Traditionally the childhood of the race was spent in a garden and no other environment has ever been found to equal it. The opportunities which it affords for child activity and the multitude of desirable interests which it stimulates cannot be over-estimated. Froebel saw it as "a true school of happy occupation" and chose the one word "kindergarten" as expressive of everything that his whole scheme of elementary education included. Gardening, indeed, stands out as the most intensive and humanly adaptable form of agriculture.

From the very dawn of history the practice of agriculture in one form or another stands out as the most universal of all forms of human occupation. To poet, philosopher, and economist alike it makes its various appeal. Both directly and indirectly it holds the common interest of mankind without respect to age or station. No matter how firmly convinced we may be as to the truth of that great saying that "Man shall not live by bread alone" we cannot well forego our gift of "daily bread" and with each returning year we hail anew the sower as "Godlike he makes provision for mankind." Let once the ponderous wheels of food production pause but for a moment and the whole world stands aghast, face to face with consternation and distress. Surely these plain facts suggest some of the reasons why the teaching of agriculture should find a place in every system of elementary and secondary education. There may also be others.

Of old, kings and sages set great store by the art of husbandry. They appreciated not only its great intrinsic value as adding to the wealth of the nation but also its importance in promoting contentment amongst the people and greater stability in government. Kings and princes then, as now, became its patrons and occasionally its leaders. Instruction in gardening and other forms of agriculture constituted a part of the training of the sons of Kings and Emperors. Then, too, the peasant in his lowly station was teaching his sons with unremitting toil how to raise such food crops as were needful for man and beast. The objectives, though different, were both essentially utilitarian.

With the passing of the centuries the art of food production has steadily been growing more complex and difficult; so much so that men have been driven to study it more closely in all its relationships with a view to discovering the laws that operate towards the achieving of success. Thus a science of agriculture has gradually been developed. More and more the art of farming is being based upon the known laws of physical, chemical, and biological science, and agriculture has come to be recognized the world over as a great composite science. He who would succeed in this "oldest of arts and youngest of sciences" must needs apply himself to careful study. Such a study must be truly scientific and is usually regarded as vocational; hence

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we have become acquainted with the descriptive phrase "vocational agriculture" now commonly used to designate courses in agricultural science as offered in American schools. Its main objective is to offer training for boys who wish to engage in farming.

But the study of agriculture in both elementary and secondary schools may be encouraged for very different and possibly more fundamental reasons, viz., for the sake of those results that may be effected in the development and character of the student himself. As the results in this case are to be measured in terms of established educational standards we may speak of this type of agricultural instruction as "educational agriculture."

Just when and by whom this concept of education *through* agriculture, rather than *in* agriculture, was originated is difficult to state. It seems, however, to have come down to us directly from the "New Science" presentation of Sir Francis Bacon (1561-1626), followed by the work of the great Moravian teacher and educational reformer, Comenius (1592-1670), from the far-reaching educational theory as presented by John Locke (1632-1704), later to be extended and more attractively presented by the intrepid educational revolutionist Rousseau (1712-1778), and finally from the new educational method of the great Swiss schoolmaster of Yverdon, Johann Pestalozzi (1746-1827). It was Pestalozzi who sought through the use of a wide range of studies, including several different branches of agriculture, to transform the lives of some "fifty little beggars" and through his unique methods to teach them "to live like men." Finally it remained for another notable Swiss educator, Fellenberg, friend and disciple of Pestalozzi, to demonstrate, largely at his own expense, the principles of realistic and naturalistic education for boys in an agricultural environment. Firm in the belief that agriculture more than any other subject offered the greatest opportunities for "cultivating the faculties and producing permanent happiness" he established at Hofwyl a great agricultural and mechanical institute for the training of boys. In conformance with Pestallozian principles, he based the teaching of the boys in various subjects upon their daily work and experiences in his great farm school. Education to him was not a preparation for life but rather life itself. Whilst in his hands, aided by a large staff of unusually gifted teachers and unhampered by financial difficulties, this remarkable demonstration of the practical working out of what might well be designated "the New Education" was eminently successful and attracted widespread attention. An attempt to institute a similar system was made in several of the leading countries including the United States but with only indifferent success. In a limited number of cases great school masters who had caught the vision and the impulse springing from the work of these great men were able to organize education on a similar basis. Perhaps no finer examples could be cited than that of the school at Bedales in England and also that of "the great school master," Sanderson of Oundle, so well described by H. G. Wells. Some of our more recent but less modern systems of agricultural education have doubtless been influenced in some measure by the achievements of these great leaders and there may yet remain some chance for the fulfilment of the wish expressed by John Griscom who visited both

Pestalozzi and Fellenberg in 1819 and who, when concluding his report on this visit, said, "I cannot but cherish the hope that this scheme of education of combining agricultural and mechanical with literature and scientific instruction, will be speedily and extensively adopted in the United States."

When the Massachusetts Horticultural Society sent Henry Lincoln Clapp, then principal of the Roxbury school, to Europe in 1890 to study the working out of elementary agricultural education, especially through the agency of the school garden, a movement was started which has had an important influence on elementary education both in Canada and the United States. In his travels throughout Europe, he found wide variation in method and objective in agricultural education as well as in details or organization and management. He found occasional civic and institutional gardens that had been in operation for centuries as well as thousands of modern gardens used entirely for instructional purposes. There were still to be found the old Eastern aesthetic culture type of garden; the exhibition or museum type of garden occasionally met with in Italy; the horticultural and botanical garden as seen in England, France, and Spain; the world-famed floral design garden of Paris; and the scientific botanical garden of Germany. Appearances differed no more widely than did the various points of view of those who engaged in the work. What was "a studious pleasure" to the man of science had been and was still "a worthy humiliation" to the mediaeval-minded monk as it had been to slaves and peasants in most of the older countries. He also found, however, that some 200 years previous to his visit, Augustus Francke had established in his famous "Institution" at Halle in Germany, not only a botanical garden for the use of the students in his higher scientific school or "Pedagogium" but also a horticultural garden for the better instruction of the boys in his orphan, or "Burgher" school. He found that from that time on several attempts had been made in different European countries to include practical studies in gardening and other forms of agriculture as part of the school curriculum. In almost but not quite all of these systems, the economic or utilitarian aspect of the study of agriculture was uppermost. The outstanding exception was Switzerland, the home of Pestalozzi and Fellenberg! Here the educational viewpoint was uppermost and from here the 20th century viewpoint was imported to America by Clapp, who the following year established at his school at Roxbury, the first school garden in America. Composed as it was exclusively of wild plants collected by the boys and girls of his school, the educational aspect of the instruction was from the first apparent.

With the dawn of the new century a new viewpoint in elementary education, sometimes referred to as the "nature-study point of view" spread rapidly throughout the United States. A great impetus was given to the movement by the epoch-making work initiated at the New York State College of Agriculture under the distinguished leadership of Dean L. H. Bailey, ably assisted by Mrs. A. B. Comstock and Mr. John Spencer. As the New York State Legislature had made a grant towards the advancement of elementary agricultural instruction, the work was taken up in earnest and summer courses were established commencing in 1898 where many teachers caught the idea and also the enthusiasm of Dr. Bailey and his co-workers. The publication

of the Cornell Series of Nature Study leaflets was of untold value in guiding the new studies along right lines. The educational viewpoint was strongly emphasized, but never to the exclusion of utilitarian values. "I stand for the spiritualizing of agriculture," said Dean Bailey, and the ideal which is reflected in this brief statement is the highest and best that has ever been set forth. It goes further than the principle of learning through doing. It points forward to the results to be achieved in the character of the learner. Neither is it the principle of knowing in order to do, and do more nobly and efficiently. It is rather learning (in the best way) in order to do (the best things) in order to become (a better citizen). True education, in short, must always be "a becoming".

During the closing decade of the 19th century, Dr. James W. Robertson was Dominion Commissioner of Agriculture. He too believed not only in improving the practice of agriculture in all its branches as Canada's chief national industry, but also in "the spiritualizing of agriculture" through education. He preached the dignity of all labor both for young and old. Not mere work alone, but thoughtful, intelligent, purposeful work tends towards true educational values. Such work always resulted in enrichment of experience. The meaning and purpose of elementary agricultural instruction as planned for Canadian schools has been well-expressed by Chief Inspector Cowley of Toronto as the "seeking of education through utility as well as utility through education." He described a school garden as "a happy field of expression, an organic part of the school in which boys and girls work among growing things and grow themselves in body and mind and spiritual outlook." This point of view is in complete harmony with that of Dean Bailey and many other educational leaders in Canada and the United States, and especially during those years when the movement was in its infancy. Unfortunately this high educational ideal has not been wholly sustained in more recent years. In Canada, as in the United States, the necessity for increased production of food stuffs during the period of the World War swept all other objectives aside. Then both elementary and secondary schools were mobilized in the common purpose of an ever-increasing agricultural production. Educational objectives were overlooked and mostly forgotten in the one overshadowing purpose of "helping the King to crush the Kaiser," as one little Canadian girl was heard to remark in all earnestness when quesitoned as to why she was making a garden. Doubtless all such children's gifts were "twice blest." The result of those hectic years of strained economic endeavor is still apparent in both Canadian and American agricultural education. Governments were aroused to provide generous financial aid for the furtherance of agriculture instruction and home making. The Canadian Federal Government voted one million dollars per year for ten years as direct aid to the provinces for the furthering of instruction in agriculture and home economics. The United States Federal Government did something similar but on a much larger scale. But legislators and government administrators always demand tangible, if not spectacular, results for moneys so expended. Obviously such material and immediate results could only be made evident through the exploitation of agricultural education on a production basis. The larger educational aspect is not so easily seen, is harder

to explain, and does not lend itself so readily to glowing reports of progress. In both countries at the present time there is a growing tendency to retreat from the high ground of original educational purpose and to fall in line with most of the European countries in considering agricultural instruction chiefly in the light of its vocational importance. This is to be regretted. Surely it would not be considered a mark of failure if few of those who study chemistry in our secondary schools should become industrial chemists or if few who study electricity become electricians.

Apart entirely from its technical or intrinsic value, the study of agriculture has a valid place on any curriculum of elementary or secondary education. It brings the student face to face with the many and varied phenomena of nature. It leads him to ask new questions about old things and trains to accurate observation and rational conclusion. Through a better understanding of scientific principles, it widens the student's interest in his whole natural environment and in the great problems of food production whether of his immediate community or of the world in general. It tends towards resourcefulness and self-reliance in experimental and demonstration work, and trains to habits of industry and close attention. Finally, it helps to make young people, girls as well as boys, more appreciative of the beauties and harmonies of nature and more reverent also in their attitude towards the sacredness of life itself.

Since the withdrawal of federal support for agricultural education in Canada in 1924, some of the provinces have had to curtail somewhat their plans and operations. The older, wealthier provinces of Ontario and Quebec have been least affected, and have made few if any changes in their respective programs. As each province has absolute autonomy in matters pertaining to education, no doubt each will in time, discover its own best way of meeting the situation. A few vocational schools of agriculture and home economics were established with the aid of the federal grant, but some of these have already been closed. Vocational short courses are offered by the various agricultural colleges and are attended mostly by young men who are already engaged in farming or who contemplate going into that work.

Agricultural courses in high schools have made considerable progress in most of the provinces, Ontario and British Columbia leading in this respect. In both of these provinces, agriculture ranks as a regular subject for credit equal with any other subject. It is one of the optional subjects and can be included only in such schools as employ specialists in science and agriculture. This means that the School Boards concerned must give their approval in all cases, and must engage properly qualified instructors to handle the work. The time occupied varies from three to five hours per week throughout two successive school years. Special financial assistance is granted by the provincial government to all School Boards that undertake the work.

The courses are made broadly educational, and may be taken by either boys or girls and the experience of all instructors has been that high school girls are quite the equal of boys in the agricultural courses. The work is conducted in the most scientific manner possible. In addition to a well-equipped agricultural laboratory, each school offering the course must estab-

lish and maintain experimental and demonstration plots for field and garden crops, flowers, vegetables and cereals. Lantern slides and reference books on all branches of agriculture are provided. Regular provision is made for frequent visits to suitable poultry and dairy farms, live stock exhibitions, fruit and experimental farms. Home projects in agriculture are carried on by the individual students.

It will thus be seen that the high school course in agriculture as organized in Canada is far from being "book agriculture." It is handled by agricultural specialists (in British Columbia, they must be graduates of an agricultural college as well as being trained teachers) and taught by the laboratory-field-lecture method. High School agriculture, as organized in Canada, therefore is made first of all broadly educational, thoroughly scientific in treatment, and only incidentally vocational. A fair percentage of the boys who take the course later go to Agricultural College, some go into teaching, and not a few go into their favorite branch of farming. Many of the girls go into teaching and become our most efficient teachers in rural schools.

Such a course in agriculture cannot fail to be beneficial to young people no matter what their chosen vocation may be. It cannot be efficiently taught along the lines indicated without being essentially practical as well as broadly cultural. What we stand in greatest need of at the present time is a better type of organization of the schools themselves, such a type of organization as will make possible large centrally located graded schools with high school departments in which good agricultural courses can be maintained.

Department of Education,
Victoria, B.C.

NOTES

FREAKS IN WHEAT AND RYE.

J. B. Harrington

[Received for publication October 10, 1927.]

In 1925 a large number of weirdly distorted spikes were found in several varieties of wheat that grew in a low, poorly drained part of the experimental farm at Saskatoon, Saskatchewan. Abnormal spikes appeared in all of the wheat varieties that were grown in this low place. These varieties represented seven different species of wheat as follows: *vulgare*—Marquis, Red Fife, Kitchener, Ruby, Kota, Red Bobs; *durum*—Acme, Mindum, Pentad, Kahla; *compactum*—Red Chaff; *turgidum*—Alaska; *polonicum*—Polish; *dicoccum*—Khapli; *monococcum*—Einkorn. All of these varieties had been grown for at least three years on the experimental farm and were reasonably pure. None of them had been known to produce abnormal spikes under normal conditions.

Various types and degrees of abnormalities were present (Figures 1 and 2). Some spikes were several times as large as normal with large distorted glumes and much twisted rachises and beards (Figure 1). Some were

Figure 1. Abnormal spikes in common and durum wheat. 1 and 2—abnormal and normal spikes, respectively, from the same plant of Kota *(T. vulgare)*; 3 and 4—normal and abnormal spikes, respectively, from the same plant of Mindum *(T. durum)*.

branched, others had branched spikelets. A number of spikes were very short and exceptionally broad. In many cases little resemblance remained between the abnormal and normal spikes of the same plant.

The cause of the abnormalities appeared to be environmental factors. The varieties were sown on May 12th and emerged around May 19th. On June 3rd an unusually heavy rain flooded the lower end of all of the rows to a depth of several inches. The water remained at the lowest part for over a week. From then on until heading the plants in this place showed lack of vigor and grew slowly; after heading nearly every plant produced deformed spikes, the amount of abnormality being greatest where the water had stood longest.

Many plants produced no normal spikes, while others had one or more normal spikes in addition to several distorted ones. Usually the normal spikes were from the main culm and the earliest tillers. Some plants showed no

FIGURE 2. Abnormal spikes of Dakold spring rye. All of these spikes were sterile. 1—spike very abnormal at base but nearly normal in upper part; 2—case where two spikes, one almost normal, were produced by a single culm; 3—case where three spikes were produced by a single culm.

abnormality although growing adjacent to plants with badly distorted spikes. No evidence was found of disease or insect injury that could have caused the unnatural growth although both stem rust and ergot were present as the plants approached maturity.

Although nearly all of the abnormal spikes were sterile, some shrivelled seeds were obtained from four of them. These, together with seeds from normal spikes of abnormal plants of eleven varieties, were sown in 1927. No

abnormal plants resulted from seed of either the normal or the abnormal spikes. Plants from abnormal seeds were shorter and less vigorous than those from normal seeds of the same mother plant. Owing to the deficient endosperms of the abnormal seeds and to the late cold spring the embryos of these seeds undoubtedly had a difficult time establishing themselves and suffered from their handicap.

Abnormalities occurred similarly in a plot of Dakold spring rye, one end of which was under water for several days. (see Figure 2).

It appears that the fantastic shapes assumed by the wheat and rye spikes as reported here were the direct result of unfavorable environmental conditions and not hereditary in nature.

University of Saskatchewan.
Saskatoon. Sask.

BOOK REVIEWS

The Legal Status of Agricultural Cooperation, by Edwin G. Nourse. (The Macmillan Company of Canada, Toronto, Ont., 1927. $3.50).

The legal status of agricultural cooperation is at present a subject of keen interest and no small amount of controversy. On this account this book is most opportune. The development of the cooperative movement to its present legal status and the changes in the attitude of the courts towards this movement are traced in considerable detail over quite a period of time. Recent changes in the attitude of the courts are given greater prominence and consideration of the possibility of further changes in the future when present conditions will have changed is not neglected.

On the whole recent decisions of the courts indicate that they have not been disposed to view with alarm the possibility of cooperative organizations becoming monopolistic in character, enhancing prices or laying themselves liable before the charge of restraint of trade. This condition prompts the author to observe that on this score the bench has revealed a keener perception of economic principles than has been indicated by some of the leaders of the cooperative movement.

This book is written by an economist who is and has been for some time devoting his attention to the problems of agriculture. Perhaps for this reason the book contains matter of greater interest to laymen not versed in the law, students of agriculture in general and students of the economics of agriculture in particular than the title would lead one to suspect.

A great deal more than an exposition of the legal status of the cooperative movement is presented. The author examines the foundation of the cooperative movement by enquiring into its underlying philosophy. The historical background emphasizes that cooperation in agriculture is not entirely a recent development. The story sometimes told of a circus advertising a side-show with the slogan "pay twenty-five cents and see what you never saw before—three farmers pulling together," loses its point altogether and much of its sting in the face of the description of a cooperative society resembling somewhat present commodity marketing organizations organizing

to slaughter, pack, and market hogs by boat as early as the year 1820 or before alternative agencies were available.

Changes in the aims and objects of the movement since that time are portrayed. Citations from platforms of some of the numerous farmer movements which the last half century has witnessed are recorded to trace this evolution. The inclusion of these, together with the more important state and federal legislation bearing on the subject and quotations from the decisions of the courts, make the text of the book replete with quotations even though footnotes are generously used.

The nature of the subject and the extent of the survey no doubt make this absolutely necessary. This also necessitates some repetition. It is difficult, however, to grasp the necessity for repeating section five of the Standard Marketing Act on page 414 after it was set forth on page 103, more especially as it is given in its entirety in Appendix D, page 471.

The object of the work is a presentation of what has occurred and the conditions which now exist. Fortunately this plan has been departed from to the extent of allowing the author some space for his own opinions which are given in the sixteenth and concluding chapter.

Appendices occupy over one hundred pages or practically one quarter of the work. The more important recent legislation concerning cooperatives, both state and federal, is included here. Several types of agreements between associations and their members are also given in the appendices.

This book deals with and confines itself to the movement in the United States. The more conversant the reader is with prevalent conditions and the machinery of government in that country, the more interesting will he find this volume. To a much wider circle this book will be interesting. In particular it will prove a valuable reference book to all interested in the aim and development of the cooperative movement, the relationship between the members and the group and the present status of this form of business organization before the bar of public opinion, as reflected by the legislatures and the courts.

J.E.L.

MANUAL OF VETERINARY BACTERIOLOGY, by Raymond A. Kelner, (Williams and Wilkins Co., Baltimore, Md., 1927).

This work is a brief manual of methods and general reference for veterinary bacteriologists. It contains morphological and cultural methods, serological tests and blood work.

The author employs the new system of bacteriological classification and nomenclature as set forth in Bergey's Manual of Determinative Bacteriology, and endeavors to present a systematic survey of those groups of microorganisms which are of special interest to the veterinarian.

The subject of parasitic protozoa is dealt with concisely but adequately for the general needs of the worker. Other material is of an informative character and should stimulate the student to consult the references and original sources of investigation.

J.R.S.

CONCERNING THE C.S.T.A.

The Eighth Annual Convention will be held at the Chateau Frontenac, Quebec City, from June 11th to June 14th inclusive, 1928. These dates were definitely agreed upon at a meeting in Quebec on October 18th, when the General Secretary and the President, with members of the Quebec local executive, held a preliminary meeting to discuss the Convention programme.

No previous Convention will approach the Quebec gathering, either in size or in the scope of the programme, or in the setting for the meetings. Quebec is the ideal Convention City. The Chateau Frontenac stands on a bluff just below the Plains of Abraham overlooking the St. Lawrence river. Ample time will be provided for sight-seeing and those who are able to attend the Convention will find much to freshen their knowledge of Canadian history. The Chateau Frontenac itself is well worth a visit. The business sessions will be held in the Jacques Cartier room and the lectures in the Parliament Buildings about a quarter of a mile from the Hotel.

The usual business sessions will be particularly important because of the expansion of the Society's activities during the current year. The change in the form of the magazine, the financial responsibilities resulting therefrom, the organization of groups within the Society, the presentation and discussion of Dean Howes' Report on Agricultural Policy, and many other important matters will keep the members' time fully occupied during the mornings.

The usual series of advanced lectures will, of course, be featured and time provided for group meetings in agronomy, animal husbandry, horticulture, etc.

It is still impossible to publish a final statement regarding the financial assistance which has been given to the official journal of the Society in its new form. Several of the Provincial Departments of Agriculture and Agricultural Colleges still have the matter under consideration and it may be some time before a complete statement can be given. In the meantime, the magazine is being maintained in the form adopted in the September issue and no immediate change of any kind is contemplated.

The General Secretary has to acknowledge a grant of $600.00 from the Chilean Nitrate Committee which has been received from their Canadian representative, Mr. B. Leslie Emslie of Toronto. The money may be used for any purpose agreed upon by the Dominion Executive Committee. In 1925 the Chilean Nitrate Committee awarded a scholarship of $600.00 through the C.S.T.A., in 1926 they made a grant of $1.000 for the organization of the Bureau of Records and Employment, and in 1927 donated $600.00 towards the payment of certain delegates' expenses to the Vancouver Convention.

Local Branches

The Macdonald College local has arranged a very extensive and interesting programme for a meeting at Macdonald College on the afternoon and evening of November 25th. Three main subjects will be fully discussed

in the afternoon:—(1) Recent developments in the improvement of field crops. (2) Recent developments in animal husbandry, and (3) The farmer's viewpoint. At the evening session, which will be concluded with a smoker, addresses will be given by Dr. J. E. Boyle of Cornell University and by Mr. L. P. Roy, President of the C.S.T.A.

Dr. J. E. Boyle, Professor of Agricultural Economics at Cornell University, will address the members of the Eastern Ontario local at Ottawa on November 24th. His subject will be "The Anarchy of Agriculture."

The Western Ontario local, in cooperation with the Provincial O.A.C. Alumni Association, will hold the annual Winter Fair banquet in Toronto on Friday, November 18th. The event will take place in the Board of Trade Chambers, 20th floor, Royal Bank Building.

To those members who pay their fees reluctantly, or question the usefulness of the Society, a perusal of the following letter may be inspiring:

Box 171, Ponce, Porto Rico.
October 12, 1927.

Dear Sir,

Although I am not actively engaged in agricultural work, still I feel that the C.S.T.A. is an organization worth while and worth belonging to. I am enclosing ten ($10) dollars which should pay up my membership until June 1929. I would like to make it more but finances will not permit just now.

Yours very truly,
(*Signed*) B. W. Morton.

Mr. Morton graduated from the Ontario Agricultural College in 1921 and joined the C.S.T.A. in 1924. If every agricultural graduate had his generous professional outlook, the Society would have found the first seven years of its history much more pleasant and would have had little need for propaganda work.

Applications for Membership

The following applications for regular membership have been received since July 1st, 1927.

C. D. Fogerty (McGill, 1925, B.S.A.), Macdonald College, P.Q.
L. A. Heitanen (Toronto, 1927, B.S.A.), Fort William, Ontario.
A. Joubert (Laval, 1924, B.S.A.) Macamic, P.Q.
T. D. Jarvis (Toronto, 1900, B.S.A.), Grimsby, Ontario.
F. X. Jean (Cornell, 1926, M.Sc.) Ste. Anne de la Pocatière, P.Q.
B. G. Montserin (McGill, 1927, B.S.A.), Macdonald College, P.Q.
J. H. McLaughlin (Alberta, 1927, B.Sc.), Spruce Grove, Alberta.
Wilfred Rodrique (Laval, 1920, B.A.) Ste. Anne de la Pocatière, P.Q.
R. S. Willison (McMaster, 1921, M.Sc.), Toronto, Ontario.
B. H. Wilson (Alberta, 1927, B.Sc.), Edmonton, Alberta.
R. M. Wilson (Manitoba, 1924, B.S.A.), Morden, Man.
L. C. Young (Mount Allison, B.A., Toronto, 1927, B.S.A.), Petitcodiac, N.B.

Notes and News

J. S. Shoemaker (Toronto '21), who is at the Ohio Agricultural Experiment Station, Wooster, Ohio, has been advanced from Assistant in Horticulture to Associate in Horticulture.

F. Godbout (Laval '25) is taking post graduate work at Macdonald College.

H. B. Boyd (Saskatchewan '23) is continuing his post graduate work in marketing at Cornell University and this year has been appointed to an instructorship in that Department.

G. J. Spencer (Toronto '14) Assistant Professor of Zoology at the University of Britiish Columbia, advises us that, until July 1, 1928, he will be located in the Department of Biology, University of Toronto.

S. G. Skinner (McGill '20) gives as his new address, 470 Willard Avenue, Toronto 9, Ontario. He is Landscape Gardener for the Canadian National Railways.

G. H. Bowen (McGill '23) is no longer in Pennsylvania. His new address is c/o Harries & Hall, 110 Franklin Street, Buffalo, N.Y.

G. S. Fraser (Toronto '21) has moved from Ottawa and his address is now 7140 Western Avenue, Montreal. He is doing chemical and bacteriological work for the Eastern Dairies Limited.

Roy West (Manitoba '26) is at the Ontario Veterinary College, Guelph, Ontario.

The address of G. F. H. Buckley (Alberta '20) of the University of Alberta, is 2230 Haste Street, Berkeley, California. He is continuing his studies towards his Ph.D. degree.

H. L. Berard (Montreal '26) is taking post graduate work at Cornell University. His address is 250 Cascadilla Hall, Cornell University, Ithaca, N.Y.

We have learned that T. P. Devlin (Alberta '25) has been transferred from the C.N.R. at Winnipeg to the C.N.R. at Saskatoon where he is now Divisional Superintendent of Colonization and Agriculture.

B. H. Wilson (Alberta '27) is taking a post graduate course at the University of Minnesota, St. Paul, Minn.

A. G. O. Whiteside (Toronto '22) is carrying on special work in the milling and baking of wheat at the University of Minnesota, St. Paul, for the Central Experimental Farm.

W. Newton (McGill '14,) has been appointed Plant Pathologist at the Dominion Experimental Farm, Agassiz, B.C.

LE BUREAU DES SOLS*

Son Origine Et Ses Buts

A. F. Woods

Directeur des travaux scientifiques, Ministère de l'Agriculture des Etats Unis

Il y aura vingt-six ans le premier juillet prochain que le Bureau des Sols fonctionne indépendamment du Département de l'Agriculture. Comme les autres bureaux agricoles du gouvernement national, il a eu son origine dans le progrès et développement naturels du département. Il vaudrait peut-être la peine de considérer les degrés de cette évolution du département et du Bureau des Sols.

Notre premier président, Washington, aurait voulu que la nation s'intéresse aux sols lorsqu'il s'exprima dans sa première dépêche au premier Congrès en 1796: "A mesure que la population d'une nation augmente, la culture du sol devrait devenir de plus en plus une affaire de considération publique." Deux choses semblent avoir contribué à cet avis, l'établissement en 1793 du ministère de l'Angleterre et les résultats qu'il avait lui-même obtenus sur les sols épuisés de_ses terres à Mount Vernon.

Nous devons nous rappeler que Washington avait l'esprit scientifique, et que par cela il devait faire des observations et des recherches dans cette branche de la science où il s'agit des sols et leur productivité. "Le premier en temps de paix," il n'était pas seulement le premier en fait de qualités sociales, dans l'art de l'ingénieur, en affaires de commerce et de diplomatie, mais il était aussi le premier à s'intéresser au biienfait public des habitants des villes et de la campagne, et par conséquence a la bonification des sols.

Les remarques de sa dépêche au Congrès au sujet de l'aide du gouvernement à l'agriculture furent reçues avec faveur, mais aucun essai pour obtenir cette aide ne réussit. Cependant, en 1839, le Commissaire des Patentes, Henry L. Ellsworth, réussit a obtenir du Congrès une allocation de mille dollars qu'on devait employer pour la collection et la distribution de graines, pour des recherches agricoles, et pour obtenir des rapports statistiques sur l'agriculture.

En 1849, le Département de l'Intérieur fut établi, et le Bureau des Patentes avec son département agricole, en fit partie.

Le deuxième degré important vers cette organisation de l'agriculture fut en 1852, lorsque se fonda la Société Agricole des Etats Unis, ayant pour but l'amélioration de l'agriculture du pays. Cette société nationale que forma une assemblée de fermiers et qui se composa de délégués choisis par les différentes sociétés des états, poussa activement l'établissement d'un département de l'agriculture des Etats-Unis. La société se réunit tous les ans jusqu'en 1860. En 1862, le président Lincoln, approuva un projet de loi pour l'organisation d'un département de l'agriculture, ce qui réalisa le désir de Washington. On doit remarquer que, dans cette même année 1862, on vota une acte pour l'établissement des collèges agricoles.

*Traduit de l'Anglais.

Dans chacun de ses trois rapports annuels du ministère, Isaac Newton, le premier commissaire d'agriculture, appuya sur la grande influence du temps et du climat sur l'agriculture et suggéra qu'on distribuât, sous la direction du gouvernement, ces renseignements sur le temps par tout le pays. Il en résulta qu'on établit d'abord, en 1872, la division météorologique du Bureau du Chef du Service de Liaison et de Transmission et, enfin, qu'on établit, en 1891, le Bureau de Météorologie comme partie du Département de l'Agriculture.

Il est étrange mais vrai que le Bureau de Météorologie fut la mère du Bureau des Sols. Telle fut la demande pour des renseignements sur les relations entre les sols et les conditions météorologiques qu'on établit, en 1894, la Division des Sols Agricoles, comme partie du Bureau de Météorologie. En 1895, on le fit un bureau, indépendant du Département de l'Agriculture, et Milton Whitney qui avait été le directeur de la division depuis son commencement devint maintenant le chef du Bureau indépendant. Il y a vingt-six ans, le premier juillet 1901, que la division fut désignée sous le nom de Bureau des Sols.

L'Oeuvre Du Bureau

La première fonction du bureau fut d'étudier l'effet que produisent la pluie et la température sur les sols, "et de tenir continuellement compte de l'humidité et de la température des types de sol les plus importants du pays," tels que les sols pour la culture maraîchère, les sols appropriés à la culture des différentes qualités de tabac, et de différentes variétés de coton et de fruits, les sols pour le blé et pour le maïs, et les sols des terrains arides ou semi-arides.

Afin d'exposer définitivement le but du bureau, et l'importance qu'il a acquise pour l'avancement et la science et les intérèts agricoles du pays, je vais noter brièvement ses oeuvres les plus remarquables: (1) Il a institué l'expertise des sols et il a créé et développé le plan de la classification des sols dont on se sert à présent; (2) il a classifié et fait l'expertise d'un total de 1,200,000 "milles" carrés ou une superficie équivalant 43 pour cent de celle des Etats-Unis; (3) il établit des méthodes pour l'étude et la classification des terrains alcalins et il a démontré comment récupérer les terres arables, perdues par l'accumulation de l'alcali; (4) il a démontré la possibilité de produire dans ce pays la plus haute qualité de tabac de Sumatra, et avec de tels résultats qu'une nouvelle industrie agricole est maintenant établie dans la vallée du Connecticut; (5) il a formulé une méthode pour l'analyse des sols qui rend possible leur classification selon la texture; (6) il a remplacé l'ancien concept statique par le concept dynamique des sols; (7) il a indiqué le rapport qu'a le type de sol à son appropriation aux produits et à la récolte; (8) il a développé de nouvelles sources de potasse, et a démontré qu'on peut recouvrer pour utiliser dans l'agriculture, comme engrais, et dans d'autres industries, de 70,000 a 100,000 tonnes de potasse qui se dissipent dans la poussière des cheminées des usines de ciment Portland; (9) il a démontré qu'il est possible de fabriquer l'acide phosphorique pour engrais, par la volatilisation du phosphore existant dans la roche qui contient du phosphate calcique soit en grande ou en petite quantité; (10) il a fait des recherches et découvert

la nature des matières organiques du sol; (11) il a formulé des méthodes pour l'étude des solutions et des colloïdes du sol.

A présent, le bureau s'occupe principalement de classifier les sols et d'en dresser la carte, à étudier la fixation de l'azote, à rechercher les sources d'engrais, et à des recherches chimiques et physiques sur les sols et leur conservation, surtout à prévenir les pertes par érosion.

Nos experts en sols constatent qu'ici, comme dans les autres parties du monde; le défaut de protection de la couche superficielle absorbante des champs et des paturages contre le dénudation à contribué à la disparition beaucoup plus rapide de l'eon qui tombe sur ces terres érodées. Le sol friable de l'horizon supérieur que l'eau a emporté, retenait bien mieux l'humidité que le sous-sol qui est relativement imperméable et que l'érosion n'à guère touché. Ces experts croient que la perte du sol compte, à lui seul, autant que tous les autres agents dans cette augmentation continuelle des inondations. Beaucoup de fleuves qui étaient navigables, il y a une génération, sont maintenant encombrés de débris de sol.

Faute de terrasser généralement les champs sur les pentes, de semer de l'herbe et de planter des arbres sur les pentes rapides ou le sol est plus susceptibles d'être enlevé par la pluie, il y a maintenant un surplus d'eau qui s'écoule dans le Mississippi.

Si de telles énormes pertes de sol ne sont pas évitées, on ne doit pas s'attendre a pouvoir enrayer les inondations. On ne fait presque rien à présent pour empêcher les inondations par ces moyens. Il n'y a pas de terrassement de talus au nord du fleuve Arkansas. Dix-huit pouces de sol supérieur ont été emportés des champs assez nouvellement cultivés de quelques parties du nord est de Kansas. Tout le sol a disparu de plusieurs centaines de mille "acres" dans l'ouest de la Virginie et de la Pennsylvanie, dans l'est du Kentucky et dans le sud-est de l'Ohio. L'eau s'écoule de ces terres au Mississippi beaucoup plus rapidement qu'autrefois. Les terrasses, les pâturages arborés, les forêts et les cultures qui lient et bonifient les sols y seront de beaucoup pour remédier aux inondations.

Non seulement ils retarderont l'écoulement de l'eau superficielle, mais ils protégeront la partie du sol ayant la plus grande valeur, et ils réduiront l'encombrement des fleuves, ce qui limite leur charge et diminue le danger d'inondation.

Ce problème de régler l'érosion, soit lente ou rapide, est je le crois, le problème des sols le plus important que nous ayons à considérer et auquel nous consacrons le moins de travail.

L'expertise des sols, sous la direction du docteur Marbut, réunit des faits sur les sols et tache de découvrir les relations qui existent entre les sols des Etats Unis. L'oeuvre fondamentale de la division pour l'expertise des sols, rend possible l'institution d'une science du sol; il facilite l'interprétation rationnelle des recherches sur les sols, et il indique le moyen de découvrir les principes sur lesquels doit se baser le traitement des sols.

A mesure que la population du monde augmente, les nations devraient de plus en plus s'occuper des moyens d'augmenter la production de la nourriture. Les ressources en engrais sont déjà devenues un problème national. Aux

Etats-Unis on étudie ce problème au Bureau des Sols. Les recherches concernant la fixation de l'azote atmosphérique sous la forme d'ammoniaque synthétique, l'utilisation comme engrais des produits azotés synthétiques, le problême des engrais concentrés, l'utilisation et la conservation économique de nos ressources naturelles de phosphates minéraux que, l'examen de nos dépôts de sables glauconifères comme source possible de potasse, et l'utilisation de résidus organiques comme source d'azote organique. Les recherches dans la chimie des sols consistent principalement dans l'étude des colloïdes du sol et la nature chimique des matériaux qui composent les sols. Beaucoup de ce travail chimique est fait en relation avec le travail d'investigation des sols. Les expériences sur les colloïdes ont jeté beaucoup de lumière sur le caractère des sols et sur les matériaux utilisés dans la construction des grandes routes.

Quoique beaucoup des premières recherches sur les sols s'occupassent des propriétés physiques des sols, on n'a encore établi aucune méthode d'analyse mécanique par laquelle les experts en sol de différentes parties du monde puissent s'accorder dans leurs interprétations d'analyses mécaniques. Le bureau a pris les devants dans beaucoup de ces travaux et récemment il à essayé de déterminer et choisir une méthode d'analyse qui puisse rendre possible une interprétation scientifique générale des propriétés physiques des sols, afin qu'il soit possible de comparer la composition physique des sols dominants d'un pays avec ceux d'un autre. Ce fait seul doit suffir à montrer comment la science du sol peut servir à encourager des recherches fécondes en fait de sols.

Selon un projet approuvé, le Bureau des Sols fera bientot partie d'un bureau nouveau et plus grand, qu'on appellera le Bureau de la Chimie et des Sols. On centralisera dans ce nouveau bureau toutes les recherches qui se feront sur la classification des sols, sur la physique, la chimie et la biologie des sols, et sur les engrais, la fertilité et la technologie des sols. Le nouveau bureau sera donc parfaitement préparé à rendre un plus grand service à l'agriculture, réalisant d'une manière pratique les rêves de nos prédécesseurs en agriculture, c'est-à-dire en fournissant cet appui gouvernemental qui fasse de l'agriculture une solide forteresse nationale.

L'AGRICULTURE INTENSIVE AUX ETATS-UNIS

Le développement de la production agricole aux Etats-Unis est-il le résultat de la mise en valeur continue de nouvelles terres ou la conséquence d'une amélioration des rendements par suite d'une culture plus perfectionnée? C'est la question que pose M. Bernard O. Weitz, économiste du Département de l'Agriculture des Etats-Unis dans une étude où il envisage uniquement quatre des grandes productions agricoles américaines: maïs, blé, avoine, pommes de terre.

Pendant longtemps, écrit-il, l'attention publique s'est presque exclusivement portée sur le développement vers l'Ouest de la production des récoltes: on vivait sur l'idée d'une abondance indéfinie des terres; de là cette opinion très répandue que la productivité des régions cultivées les premières n'a fait que décroître et que le volume de la production nationale n'a pu être conservé, ou accru, que grâce à la mise en exploitation de nouvelles terres vierges.

Mais maintenant que presque toute la terre arable est cultivée et alors que la population ne cesse de s'accroître fortement, le problème de la productivité et de la fertilité du sol s'impose à l'attention de tous ceux qui s'inquiétent de l'avenir du ravitaillement national. Ils se demandent s'il est vrai que l'augmentation de la production agricole américaine n'a été due qu'à l'augmentation des superficies utilisées, et s'il est vrai qu'il n'y a eu aucun progrès des méthodes agricoles dans la partie la plus anciennement cultivée des Etats-Unis, que certaines même des terres qui la composent ont été abandonnées par suite de la réduction incessante des rendements, alors qu'au contraire les vieilles terres de l'Europe donnent des rendements toujours plus forts.

Ces rumeurs pessimistes ne sont pas fondées, affirme M. O. Weitz: "Les statistiques des rendements à l'acre de nos principales récoltes, le coton excepté, montrent une tendance à l'augmentation de ces rendements depuis un demi-siècle." Et il s'efforce de le démontrer au moyen de diverses statistiques d'où nous extrayons les deux tableaux suivants montrant, l'un l'augmentation des surfaces cultivées, l'autre l'augmentation des rendements moyens à l'acre.

Surfaces cultivées:

	Superficie annuelle (Moyenne 1885-1889) acres	Superficie annuelle (Moyenne 1920-1924) acres	Augmentation %
Maïs	73.796.000	102.737.000	39
Blé	35.911.000	59.836.000	67
Avoine	25.536.000	42.503.000	66
Pommes de terre	2.409.000	3.814.000	58

Boisseaux à l'acre:

	Moyenne 1883-1887	Moyenne 1921-1925	Augmentation %
Maïs	23,4	27,7	18
Blé	11,9	13,9	17
Avoine	27,0	30,9	14
Pommes de terre	76,9	107,4	39

Ainsi donc l'augmentation, depuis 40 ans, de la production agricoles des Etats-Unis a résulté pour une grande part de l'utilisation de nouvelles terres; mais il est certain que les effets de l'élévation des rendements à l'acre sur le volume de cette production ont été sous-estimés. Il résulte d'un diagramme dressé par M. O. Weitz que, pendant cette période, la superficie couverte par les quatre grandes récoltes considérées a augmenté de 52%, mais que leur production s'est accrue de 77.%

Voilà la réponse générale du problème posé; mais il convient d'entrer dans le détail pour rechercher quelle est la part des terres neuves de l'Ouest et des vieilles terres d l'Est dans cette amélioration dc la productivité de l'agriculture américaine.

L'amélioration a été remarquable surtout dans les Etats qui bordent l'Atlantique, à un degré moindre dans les Etats limitrophes, plus à l'ouest, des grands lacs: Ohio, Indiana, Michigan, etc., et même dans quelques Etats du groupe nord-ouest central: Minnesota, Iowa, etc....D'une façon générale, les Etats ci-dessus visés comprennent les régions les plus anciennement cultivées aux Etats-Unis.

Sans passer en revue chacun de ces Etats et chacune des productions agricoles, nous grouperons en un seul tableau les chiffres représentant, pour l'ensemble des quatre récoltes considérées et pour les trois groupes d'Etats les plus intéressants, d'abord la surface cultivée, puis la production totale, enfin le rendement moyen à l'acre. Les chiffres du tableau expriment les quantités moyennes obtenues pour la période 1920-1924 par comparaison avec les quantités de la période 1885-1889, ces dernières étant représentées par le chiffre 100.

	Pourcentage en 1920-1924
Middle Atlantic States (1):	
Superficie	90
Production totale	131
Rendement à l'acre	145
East North Central States (2):	
Superficie	120
Production totale	150
Rendement à l'acre	125
Partie septentrionale des South-Atlantic States (3)	
Superficie	87
Production totale	155
Rendement à l'acre	177

(1) New-York, New-Jersey, Pennsylvanie.
(2) Ohio, Indiana, Illinois, Michigan, Wisconsin.
(3) Maryland, Delaware, Virginie, Virginie Occidentale, Caroline du Nord.

Par contre, dans les Etats où les quatre grandes cultures ont été étendues aux régions à moitié arides, le niveau du rendement a baissé, entraînant la réduction ou empêchant l'élévation du rendement national moyen. Tel a été le cas dans le Kansas et le Missouri, par exemple.

Dans l'ensemble l'agriculture extensive est en voie de recul aux Etats-Unis et l'emploi des méthodes scientifiques pour accroître la productivité du sol en progrès. Il est téméraire de chercher à prévoir l'avenir; cependant on peut dire que la demande croissante de denrées alimentaires pour une population qui ne cesse d'augmenter doit finalement provoquer l'établissement de niveaux de prix qui justifieront de plus en plus au point de vue économique l'emploi des méthodes perfectionnées de production.

ACTIVITES DES SECTIONS

Reunion de la Section de Ste. Anne de la Pocatiere

La Section de Ste-Anne des Agronomes Canadiens se réunissait, mardi soir, le 4 octobre, à l'occasion de l'exposition de chevaux, pour entendre un confrère de la section de Québec les entretenir de l'élevage du cheval dans notre province. Mons. Gaudreau exposa à son auditoire les conditions peu satisfaisantes de l'élevage de l'espèce chevaline et donna les moyens à prendre pour remédier à cet état de chose. Il nous fit remarquer que durant les trois premiers mois de l'année écoulée l'on importa 10,000 chevaux de l'ouest, au prix moyen de $100.00 chacun. Le conférencier nous dit ensuite quelques mots de la formation des centres d'élevage et cita celui du comté de Kamouraska, comme un des meilleures pour l'élevage du cheval percheron, et il conseilla la centralisation des cercles.

Mons. Gaudrau parla ensuite de l'inspection des étalons, des règlements concernant cette inspection et des bons succès obtenus. Le conférencier termina en demandant à ses confrères de coopérer davantage à l'élevage du cheval dans notre province. Il ne s'agit pas tant de faire l'élevage sur une base commerciale que d'être en mesure de répondre aux demandes locales.

Mons. J. A. Ste-Marie, président de la section, qui avait présenté le conférencier, demanda à Mons. Georges Bouchard, M.P., du comté de Kamouraska, de remercier Mons. Gaudreau, ce qu'il fit avec beaucoup de tact, tout en profitant de l'occasion pour donner des conseils très sages, par rapport aux activités de notre section.

Notes

De divers côtés, nous avons reçu des félicitations concernant la nouvelle toilette de la Revue agronomique. "Telle qu'elle est actuellement, la revue a grande apparence et peut être comparée sans hésitation aux meilleures publications des Etats-Unis ou de l'Europe," nous écrit notamment un de nos aimables correspondants.

Le texte français est certainement le premier à bénéficier de l'impression en une seule colonne, ce qui diminue les coupures des mots par le milieu de la syllable, inévitables de la part de typographes anglophones, qui ne peuvent évidemment pas saisir la structure des mots d'une langue qui leur est inconnue. Voici donc l'occasion de faire un nouvel appel au dévouement des membres français, dont la collaboration est vraiment trop parcimonieuse.

Nous apprenons que monsieur A. G. Gilbert, assistant agronome à la Station Expérimentale de Ste. Anne de la Pocatière, vient d'être nommé à la Division des céréales, à la Ferme expérimentale centrale d'Ottawa. Son adresse privée est actuellement 123 rue Rideau, Ottawa.

Monsieur Gérard Tremblay, jusqu'ici professeur à l'Institut Agricole d'Oka, est devenu propagandiste pour l'Association d'élevage du bétail Ayrshire. Ses activités couvrent tout l'est du Canada, c'est-à-dire l'est de la province d'Ontario, Québec et les Provinces Maritimes.

Un retard dans la réception de la lettre nous a empêché d'annoncer jusqu'ici que monsieur Ch. Perrault, du collège Macdonald, a été nommé, au mois de juillet dernier, assistant phytopathologiste au Laboratoire de phytopathologie du Dominion, à Ste-Catharines, Ont.

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THE HARDNESS OF THE WHEAT KERNEL IN RELATION TO PROTEIN CONTENT.

R. Newton, W. H. Cook, and J. G. Malloch.

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Introduction

In the commercial grading of wheat the texture of the kernel has long been used as an index to its quality for milling and baking purposes. The percentage of "hard red vitreous kernels" (Canada), or "dark hard vitreous kernels" (United States), is specified in the regulations for various grades. The assumption is that these vitreous kernels contain more protein than the "soft starchy" and "piebald" kernels, and the common belief that the former are also harder than the latter is implied in the terminology used. The experiments reported in this paper were designed to test the validity of these assumptions.

Review.

The relation between kernel texture, protein content, and baking quality has been the subject of frequent investigation. No factor has yet been discovered which shows an entirely consistent relation to baking quality, but protein content has at least a general relation to this property. In fact, Coleman, Dixon and Fellows, (*1*) concluded as a result of statistical studies of the crops of 1923 and 1924, that a crude-protein determination, either on the wheat or on the flour milled from it, was the best single-factor test of baking value. A significant positive correlation between protein content and baking quality was also found by Mangels and Sanderson (*4, 6*) in a majority of the crop seasons covered by their investigations. It becomes of importance, therefore, to know the relation between protein content and the physical characteristics of the kernel on which commercial grading is largely based.

Shollenberger and Coleman (*9*) found on the average 2.4 per cent. more protein in dark kernels as compared with starchy kernels. Mottled kernels were intermediate in quality. They point out, however, that these differences were based on a comparison of these types of kernel texture within the same sample. When samples of the same variety grown under different conditions were subdivded into dark, mottled, and starchy types, the best (dark) fraction of one sample might on occasion show a lower protein content than the poorest (starchy) fraction of another.

In one of the papers already cited, Mangels and Sanderson (*6*) report a significant positive correlation between protein content and percentage of "dark hard" kernels in the crops of two out of three seasons studied, with a slight positive correlation in the third season. In a later paper including a fourth season's results, Mangels (*5*) showed that frequency distributions of representative samples of the North Dakota spring-wheat crop on the basis of protein content were skewed to the left, while distributions on the basis of dark kernel content were skewed to the right. When the samples were classified according to dark-kernel content, he found that those with high percentages showed almost as great a range of protein content as the unclassified samples. When in addition he found that the calculated coefficient of correlation varied considerably from season to season, and might be quite low, he concluded that the colour of the kernel was not a sufficiently accurate index of protein content to be used by the wheat buyer.

It should be noted that the term "hard" as used in the grading regulations, and frequently quoted, as in the papers cited above, is practically synonymous with "dark" or "vitreous." It is based on the external appearance of the kernels, possibly supplemented on occasion by a biting test or by cutting with a knife, but only a few workers have attempted to measure actual hardness quantitatively.

Harper and Peter (*3*) devised a machine to measure the pressure required to cut a kernel transversely. It consisted of a piston working vertically, with a cutting edge at the bottom. They recorded the number of kernels in 100 cut in two by a weight of 4 lbs. placed on top of the piston. Their comparisons included both hardness and protein content of flinty and starchy kernels selected from a number of varieties. The flinty kernels in all cases contained more protein, the average difference being 3.2 per cent. Within a given variety they were also distinctly harder than the starchy kernels, but in comparing different varieties there appeared no definite relation of this sort.

Shaw and Gaumnitz (*10*) mounted a pair of ordinary pincers horizontally, with a weight attached to the upper arm by means of a wire. Five lots of 100 kernels each were counted out from each sample to be tested, and the hardness based on the number remaining unbroken within the jaws of the pincers by weights of 0.75, 1.00, 1.25, 1.50, and 1.75 lbs. respectively. The authors state that a number of more complicated arrangements were tried, but none seemed to give more uniform results than this simple contrivance, the action of which approximated the biting method. They found that hardness increased with size of kernel and weight per bushel, but apparently was not related to the milling value of different varieties. No attempt was made to classify kernels as to texture, or to show the relation of hardness and protein content.

Roberts (*7*) designed a much more complicated apparatus which measured wheat kernel hardness probably more accurately than either of the foregoing. His method was also different in that it involved crushing between two flat surfaces rather than cutting or cracking the kernels, and

in that the exact crushing point of every kernel was determined. He studied statistically the number of kernels it was necessary to crush in order to obtain the correct mean crushing-point of a pure strain of wheat. This was found to be 350, though in later work (*8*) he used 500 grains of each sample. Before crushing, the kernels were dried for 7 days at the temperative of boiling water, and stored in a desiccator while the work was in progress. They were placed always in the same position with reference to the crushing surfaces, i.e., crease downwards.

In his later work, Roberts (*8*) tested by this method the hardness of 94 pure strains of wheat varying in protein content from about 10 to 15 per cent. The correlation coefficient for the relation of hardness to protein content turned out to be 0.02 ± 0.003. Since this was contrary to common opinion, Roberts examined statistically the data published by other workers. For those of Harper and Peter he found a correlation coefficient of 0.03 ± 0.159, and for Shaw and Gaumnitz, 0.01 ± 0.06.

Roberts states, in conclusion, that he "is at a loss thus far to account for the conflict between the generally recognized fact, on the one hand, that the higher protein wheats are the harder wheats, and the entire absence of demonstrable correlation between protein content and hardness by means of the correlation coefficient, on the other." The importance of the point appeared to justify the further investigation reported in the following pages, which it was hoped might suggest some explanation of the discrepancy.

Experiment.

Samples of six standard varieties of wheat, grown at six western stations in 1924 from seed produced at Edmonton in 1923, were studied in regard to kernel texture, protein content, and hardness. Residual samples of the Edmonton stock seed of 1923 were included with the test samples. The varieties consisted of five of the hard red spring type, namely, Red Fife, Renfrew, Marquis, Ruby, and Huron; and one durum, Kubanka. The stations cooperating in the production of the 1924 samples were Lethbridge, Brooks, Edmonton, Beaverlodge, Fort Vermilion, and Vancouver.* At Brooks the crop was grown under irrigation, and at Lethbridge both under irrigation and on dry land.

The kernel texture was estimated by counting the number of vitreous, mottled or piebald, and starchy kernels in a sample of one thousand. For crude protein, a modified Kjeldahl method was used, and percentages were recorded on the dry basis. Hardness was determined by measuring the strain required to crack the kernels transversely, in the machine described below.

Certain features of the experiment distinguish it from the earlier work on the quantitative measurement of wheat kernel hardness reviewed in the preceding section. Important factors taken into account, which did not seem to have been sufficiently considered previously, included moisture

*The Experimental Station at Lacombe, Alberta, also cooperated in this work, but unfortunate weather conditions in the season of 1924 so damaged the wheat plots at that station as to make it necessary to discard the samples.

content and size of kernel. The method of cracking devised also seemed to have some advantages over those already described. Further, the use of a series of samples of each of a number of pure varieties grown under different conditions made it possible to observe whether there might exist inherent tendencies which modified the relation between hardness and protein content.

The Determination of Hardness.

The quantitative determination of hardness presented a somewhat difficult task. The object was to measure differences in hardness caused by variations in the physical or chemical composition of the kernel. It was necessary to account in some way for the effect of other variables, notably moisture content and size of kernels.

Moisture Content.

Roberts (*7, 8*) overcame moisture effects by crushing the kernels in an oven-dry condition. This, however, is very different from the state in which kernels are normally examined by a buyer, and furthermore, when some preliminary tests were made, the brittleness of the oven-dry kernels caused them to break at lower pressure than those in the air-dry state. It was concluded that high-protein wheat would possess greater resilience and show greater apparent hardness in the air-dry condition. Accordingly the test samples were brought to a standard moisture content by storing them in shallow layers in an atmosphere of 71 per cent relative humidity, at room temperature. Samples thus stored were removed for cracking and replaced by others in rotation, so that all were tempered for approximately the same length of time, usually about a month. Only sufficient kernels for the hardness test were tempered in this way, the kernel texture and protein content being determined on other portions of the original bulk samples. The desired humidity for tempering was maintained in large desiccators by a solution of 40 g. KOH in 100 cc. water. This brought the kernels to a moisture content of about 12 per cent., although changes in room temperature were found to affect the equilibrium appreciably. The protein content of the wheat had no evident effect on the hygroscopic moisture, a point which has been examined more fully by Coleman and Fellows (*2*).

Size of Kernel.

Shaw and Gaumnitz (*10*) found that hardness, as measured by their method, increased with size of kernel. Such a result appears inevitable when the breaking strain of every kernel is given equal value in the computation of hardness. In cutting or breaking a kernel transversely, the strain required would be expected to bear a relation to the cross-sectional area, and differences in size may be approximately compensated if the diameter of the kernels is known. In a crushing method such as that used by Roberts (*7*) it would appear that compensation for size difference should be based on the volume of the kernels. However, the stresses involved in crushing would seem to be more complicated than those coming

into play when the kernel is merely cracked across the centre. Possibly this relationship explains in part the apparently greater accuracy of the method adopted here, as shown by data presented later (Table 1) in regard to the number of kernels to be cracked in order to secure a reliable mean cracking strain. The probable error as a per cent. of the mean for any given number up to 500 was found to be less than half that shown by Roberts' data on the same point. This result was secured on the basis of the direct cracking strain, uncompensated for size variations.

In our main experimental series (Table 3), both the volume and diameter of the kernels were determined. The average volume was calculated from the specific gravity and weight per 1,000 kernels, factors which had been determined in connection with other studies of the same samples of wheat. The diameter of every kernel cracked was measured as described below. Both volume and diameter were used in the derivation of hardness factors.

The Hardness Machine.

A machine devised many years ago by the Field Husbandry Department of the Ontario Agricultural College, and found in a number of Canadian laboratories, was on hand when this work was begun. In principle of operation it was very much like that used by Shaw and Gaumnitz (*10*) in the California investigations. An ordinary pair of pincers was mounted vertically, with the jaws at the top. One arm was rigidly fixed to a standard, while the free arm was attached by a cord to a spring balance lying in a horizontal position. To the other end of the spring balance was attached by another cord a hand-operated windlass, the turning of which transmitted to the pincers a tension indicated on the balance. One of the most obvious disadvantages of the arrangement was that the pressure required to crack the kernel had to be read before the point of cracking was actually reached, since the pointer of the spring balance jumped back when the pressure was released.

The first improvements of the foregoing device made by the present writers were to add to the spring balance a vernier which did not jump out of place when the kernel cracked, and to attach to the free jaw of the pincers a long pointer which indicated the diameter of the kernels on a scale graduated to fifths of millimeters. In preliminary experiments, however, it was found that errors of a large magnitude were caused by friction changes in the pincers. The machine was also slow and inconvenient of operation, a particular disadvantage in view of the large number of kernels which had to be cracked to overcome individual variations. It was therefore replaced by a new device which satisfactorily overcame the difficulties.

The essential parts of the new mechanism are shown in Figure 1. A right-angled beam *B* balances on a knife-edged fulcrum *F*, the horizontal portion, including the pointer *P*, being counterpoised by *C*, a lead weight. The lower end of the beam is connected by the wire *W* to the spring balance

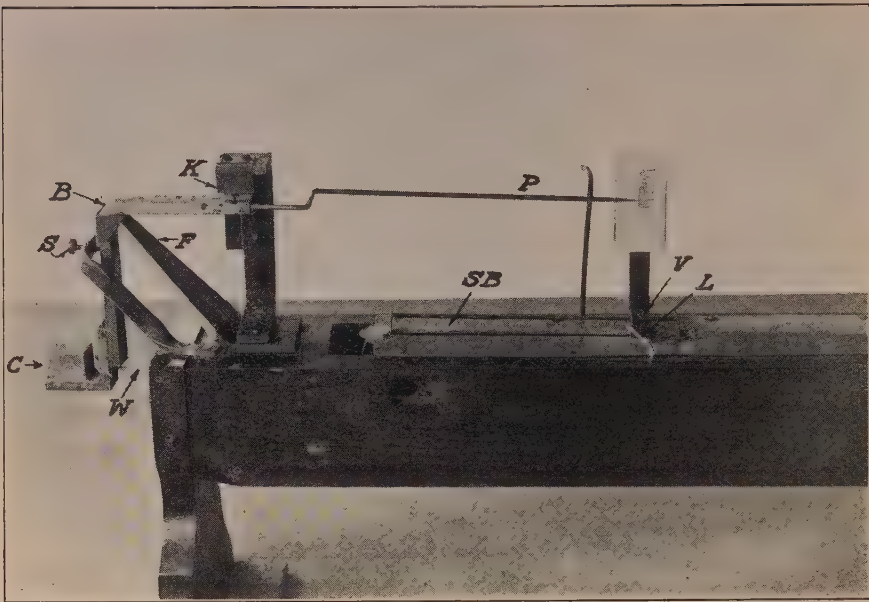

FIGURE 1.—Wheat kernel cracking machine. Description in text.

SB. To the other end of the balance is attached a cord leading over a pulley to a foot lever (not shown in figure). Pressure upon the foot lever slides the balance to the right, the pointer of the latter carrying before it the vernier *V*, which makes it possible to read the strain to 0.02 kg. A second spring (not shown) under the balance carries it back to the starting position when the foot lever is released, the vernier being returned at the same time by contact with the stationery lug *L*.

The kernel to be cracked is placed in a groove in the beam under the rather obtusely-edged knife *K*. When the kernel cracks, the cutting edge of the knife is protected from impact with the metal beam by dropping into a second groove, suitably shaped to support only the shoulders of the knife. The distance from the fulcrum to the point on the beam where cracking takes place is equal to that from the fulcrum to the point of attachment of the wire leading to the spring balance, so that the reading on the balance gives the true cracking strain directly. The pointer *P* moves over a scale graduated to 0.2 mm., and by interpolation the diameter of kernels is recorded to 0.1 mm. The diameter is read at a standard pressure of 0.5 kg.

An arm rest and small feeding platform are not shown in the figure, having been removed to avoid obscuring the cracking mechanism. The feeding platform contains a groove in which the kernels slide, this being continuous with the groove in which they rest while being cracked. The screw *S* is used to adjust the height of the horizontal part of the beam when at rest, so as to bring it level with the feeding platform.

The friction of this machine is small, and what is more important, it is constant. It is also more rapid in operation than the older form, an

average rate being about 100 kernels per hour. The use of the foot lever leaves the operator free to record the diameter and cracking strain with his right hand, while the kernels are placed in position with his left. In carrying out the tests, kernels were placed on their side, as experience showed that more constant results were secured this way, and the possibility of splitting along the suture was also obviated.

Size of Sample.

To determine the number of kernels to be cracked in order to secure a sufficiently reliable mean, three varieties were selected which showed considerable variation in kernel size and type, namely, Ruby, Renfrew and Kubanka. Of each of these 700 kernels were cracked, and the data thus obtained treated statistically in groups of 100 to 700. The mean cracking strains and probable errors are given in Table 1. These data show that even for 100 kernels the probable error is quite small, while the interval from 100 to 200 accounts for about half of the total change from 100 to 700.

TABLE 1.—*Mean cracking strains and probable errors for samples of various sizes.*

	Ruby (Leth. dry land, 1924)		Renfrew (Ft. Vermilion, 1924)		Kubanka (Leth. dry land, 1924)	
No. of kernels in sample	Mean cracking strain	Probable error as % of mean	Mean cracking strain	Probable error as % of mean	Mean cracking strain	Probable error as % of mean
100	3.43 ± 0.019	0.55	4.88 ± 0.020	0.41	4.60 ± 0.020	0.45
200	3.44 ± 0.012	0.35	4.91 ± 0.015	0.29	4.66 ± 0.015	0.32
300	3.44 ± 0.009	0.25	4.92 ± 0.012	0.24	4.70 ± 0.014	0.29
400	3.44 ± 0.008	0.24	4.91 ± 0.010	0.20	4.70 ± 0.012	0.26
500	3.43 ± 0.006	0.19	4.92 ± 0.010	0.20	4.68 ± 0.011	0.24
600	3.44 ± 0.007	0.19	4.93 ± 0.008	0.17	4.68 ± 0.010	0.22
700	3.46 ± 0.006	0.18	4.92 ± 0.008	0.17	4.68 ± 0.009	0.20

In the data of Table 1, no consideration is given to size variations in the kernels. The apparent differences in the hardness of the three varieties may be explained almost wholly on this basis (cf. Table 3), Renfrew having the largest kernels and Ruby the smallest. However, within a given sample the diameter of the kernels is relatively constant, so that the magnitude of the probable error would not be more than slightly reduced by compensating for size differences.

As Roberts pointed out (*7*), it is desirable to determine the rate of decrease of the error of the mean cracking strain for successively larger numbers of kernels cracked. From the data in Table 1 an approximate equation was derived for the curve of the percentage error for each variety, of the type

$$E = bn^a,$$

where E is the per cent. error, b is a constant, n is the number of kernels cracked, and a is the constant exponent which gives the change of slope. On differentiation, dE/dn is equal to the slope of the curve, or the rate of change of error (in this case decrease) at any point. The derivatives so obtained for 100, 200, 300 and 700 kernels are given in Table 2. They show that the curve is very flat at $n = 200$, falling only very gradually after

TABLE 2.—*Rate of decrease of error with increasing number of kernels.*

Sample	n	dE/dn
Ruby (Lethbridge, dry land) 1924	100	–0.0039
" " " " "	200	–0.0012
" " " "	300	–0.0006
" " " " "	700	–0.0001
Renfrew (Fort Vermilion) 1924	100	–0.0020
" " " "	200	–0.0008
" " " "	300	–0.0004
" " " "	700	–0.0001
Kubanka (Lethbridge, dry land) 1924)	100	–0.0016
" " " " "	200	–0.0007
" " " " "	300	–0.0004
" " " " "	700	–0.0001

that point. With the small initial error and the slow decrease beyond 200 kernels, it was considered that 250 kernels were a sufficient number to crack, and a sample of that size was adopted. In the experimental series, the arithmetic mean cracking strains of the samples were used, rather than means obtained by class distribution.

RESULTS.

The kernel texture, diameter, volume, cracking strain, hardness factors, and protein content of the wheats investigated are presented in Table 3. Two hardness factors are shown. Hardness factor *a* is obtained by dividing the strain in kilograms by the diameter in millimeters, thus giving a result in kilograms per millimeter. Hardness factor *b* is based on the same relationship between strain and volume, the resulting figures being divided by 100 to facilitate plotting and comparing both factors on the same scale.

In the table, the samples are grouped by varieties, as grown in different localities and years. Incidental interest attaches to the evident effect of season and soil on the protein content, but discussion of this point will be reserved for a later paper. The grouping by varieties also makes it possible to form by inspection some idea as to whether hardness and protein content tend to vary together, when inherent differences in structure of kernel are ruled out. However, no relation of this sort can be observed; consequently a high degree of mathematical correlation cannot be expected.

A number of correlation coefficients calculated by Pearson's linear formula from the data in Table 3 are reported in Table 4. The first two of these are the only ones which bring out significant relationships. These show that the cracking strain increases with the size of the kernel, and that a correction must therefore be introduced in making comparisons of samples differing in kernel size. The third correlation was worked out to see if dividing the strain by the diameter was a satisfactory way of making this correction. Hardness factor *a,* which is derived in this way, shows no correlation with size of kernel as expressed by the diameter. This indicates that the influence of size on hardness (as expressed by hardness factor *a*) has been removed, and seems to justify the use of factor *a* as a comparative measure of hardness.

TABLE 3.—*Kernel texture, size, hardness, and protein content of wheats investigated.*

Variety	Station and year	Kernel texture: Vitreous	Kernel texture: Piebald	Kernel texture: Starchy	Av. diameter	Av. volume	Av. strain	Hardness factor a (strain / diam.)	Hardness factor b (strain / vol. x 100)	Protein content
		%	%	%	mm.	cc.x100	kg.			%
Red Fife	Leth. (dry)† 1924	77.8	8.5	13.7	2.54	2.28	3.66	1.44	1.60	18.7
	Leth. (irr.)‡ 1924	78.6	9.6	11.8	2.59	2.55	4.80	1.78	1.88	15.1
	Brooks (irr.) 1924	69.2	20.3	10.5	2.57	2.28	3.99	1.55	1.75	12.3
	Edmonton 1923	83.3	5.4	11.3	2.68	2.65	4.36	1.63	1.64	14.9
	Edmonton 1924	60.8	35.6	3.6	2.62	2.42	4.53	1.73	1.87	16.3
	Beaverlodge 1924	68.9	12.0	19.1	2.70	2.25	4.46	1.65	1.98	18.7
	Ft. Vermilion 1924	87.3	4.2	8.5	2.67	2.55	4.17	1.56	1.64	15.1
	Vancouver 1924	89.3	8.7	2.0	2.66	2.22	4.22	1.59	1.90	13.1
Renfrew	Leth. (dry) 1924	90.5	5.8	3.7	2.63	2.56	4.30	1.63	1.68	16.4
	Leth. (irr.) 1924	79.2	18.2	2.6	2.83	2.92	5.74	2.03	1.97	14.2
	Brooks (irr.) 1924	65.2	25.0	9.8	2.58	2.64	4.60	1.78	1.74	12.4
	Edmonton 1923	92.5	1.0	6.5	2.77	2.96	5.20	1.88	1.76	13.9
	Edmonton 1924	76.1	19.9	4.0	2.64	2.85	5.02	1.90	1.76	14.9
	Beaverlodge 1924	67.6	25.6	6.8	2.73	2.63	5.74	2.10	2.18	15.7
	Ft. Vermilion 1924	74.2	13.7	12.1	3.00	3.00	4.76	1.59	1.59	13.4
	Vancouver 1924	47.0	46.6	6.4	2.75	2.57	5.00	1.82	1.94	11.8
Marquis	Leth. (dry) 1924	94.8	2.1	3.1	2.52	1.98	3.72	1.48	1.88	17.3
	Leth. (irr.) 1924	85.3	10.8	3.9	2.80	2.56	4.38	1.59	1.71	15.6
	Brooks (irr.) 1924	67.0	24.2	8.8	2.79	2.41	4.35	1.56	1.80	12.9
	Edmonton 1923	89.1	1.0	9.9	2.74	2.55	4.20	1.53	1.65	14.8
	Edmonton 1924	80.4	15.5	4.1	2.71	2.49	4.30	1.59	1.73	16.4
	Beaverlodge 1924	63.5	27.2	9.3	2.60	2.09	4.56	1.75	2.18	17.8
	Ft. Vermilion 1924	75.9	12.3	11.8	2.92	2.59	4.60	1.58	1.78	14.9
	Vancouver 1924	81.4	15.5	3.1	2.66	2.10	4.39	1.65	2.09	13.7
Ruby	Leth. (dry) 1924	91.4	4.6	4.0	2.37	1.85	3.52	1.48	1.90	17.6
	Leth. (irr.) 1924	82.6	12.9	4.5	2.46	2.06	4.25	1.73	2.06	17.2
	Brooks (irr.) 1924	75.2	10.5	14.3	2.52	2.02	4.01	1.59	1.98	13.8
	Edmonton 1923	94.7	0.9	4.4	2.33	1.92	3.16	1.36	1.65	16.3
	Edmonton 1924	84.9	8.9	6.2	2.38	2.00	4.41	1.85	2.20	18.2
	Beaverlodge 1924	60.1	13.1	26.8	2.42	1.93	4.48	1.85	2.32	17.7
	Ft. Vermilion 1924	97.4	2.3	0.3	2.64	2.50	4.53	1.72	1.81	15.9
	Vancouver 1924	92.7	6.5	0.8	2.58	1.97	4.15	1.61	2.11	15.1
Huron	Leth. (dry) 1924	86.2	6.9	6.9	2.46	2.37	4.03	1.64	1.70	17.4
	Leth. (irr.) 1924	91.1	5.1	3.9	2.63	2.70	4.46	1.70	1.65	15.7
	Brooks (irr.) 1924	78.3	15.9	5.8	2.23	2.34	4.36	1.96	1.86	13.4
	Edmonton 1922	92.0	3.3	4.5	2.42	2.35	3.56	1.47	1.51	17.1
	Edmonton 1924	81.2	16.4	2.4	2.48	2.74	4.84	1.95	1.77	15.6
	Beaverlodge 1919	96.2	3.8	6.0	2.66	-	4.68	1.76	-	14.5
	Beaverlodge 1924	83.9	11.6	4.5	2.35	2.33	4.74	2.02	2.03	16.1
	Ft. Vermilion 1924	88.5	7.1	4.4	2.73	2.85	4.64	1.70	1.63	15.6
	Vancouver 1924	87.3	11.3	1.4	2.64	2.43	4.58	1.73	1.88	12.9
Kubanka	Leth. (dry) 1924	96.4	1.5	2.1	2.81	3.18	4.72	1.68	1.48	16.4
	Leth. (irr.) 1924	91.5	6.3	2.2	2.77	3.36	5.92	2.14	1.76	15.6
	Brooks (irr.) 1924	41.5	29.4	29.1	2.66	3.03	4.83	1.82	1.59	11.5
	Edmonton 1923	83.6	8.9	7.5	2.40	2.70	5.09	2.12	1.88	15.9
	Edmonton 1924	88.4	9.1	2.5	2.55	2.91	5.36	2.10	1.84	15.3
	Beaverlodge 1924	79.2	12.7	8.1	2.74	2.96	6.80	2.48	2.30	16.8
	Ft. Vermilion 1924	92.9	4.2	2.9	2.82	3.11	5.33	1.89	1.71	15.0
	Vancouver 1924	74.2	22.8	3.0	2.66	3.17	7.16	2.69	2.26	13.6

†, ‡ Dry land and irrigated wheat respectively.

It had been intended to work out the relation between cracking strain and some squared function of the diameter approximating the cross section of the kernel.. However, the main purpose of the investigation was to discover what relation existed between hardness and protein content. As no significant relation of this sort could be shown on the basis of either hardness factors *a* or *b* (in spite of the high correlation of strain with volume, from which factor *b* was derived) it appeared beside the point to enter upon further laborious calculations of the relation of strain to other size functions.

Table 4.—*Correlations from data in Table 3.*

No.	Values correlated	Correlation coefficient
1	Strain with diameter	0.41 ± 0.08
2	Strain with volume	0.73 ± 0.05
3	Hardness factor a with diameter	0.04 ± 0.14
4	Strain with protein content	−0.23 ± 0.09
5	Hardness factor a with protein content	−0.12 ± 0.09
6	Hardness factor b with protein content	0.16 ± 0.09
7	Vitreous kernels* with protein content	0.24 ± 0.09
8	Vitreous kernels* with hardness factor a	−0.16 ± 0.09

*Half the per cent piebald kernels was added to the per cent vitreous kernels for the purpose of this correlation.

The fourth correlation shown in Table 4, that between strain and protein content, is comparable with those calculated by Roberts (8). That it shows no significant value is not surprising, since the data used took no account of size differences. The coefficient, such as it is, has a negative sign, a result possibly associated with the tendency, under favourable growing conditions, for the yield and kernel size of wheat to increase somewhat at the expense of protein content. In the hardness factors considered in the fifth and sixth correlations, however, size differences had been compensated, and it is somewhat surprising to find no significant relation between these factors and protein content. The same unexpected result is found in the seventh and eighth correlations, between vitreous kernels and protein content, and vitreous kernels and hardness factor *a*, respectively.

The foregoing results were the more surprising since within a given sample the vitreous kernels are almost always harder and higher in protein than the starchy kernels. (Cf.. Table 5). They led to the speculation that there might actually exist a curvilinear relation which could not be demonstrated by Pearson's formula. As the variates were not sufficiently numerous to make possible the use of the correlation ratio, they were plotted in various ways to see what could be demonstrated graphically.

When the samples were grouped according to protein content, and mean cracking strain plotted against given protein contents, the resulting graph was decidedly curved. However, a close inspection of the data showed that the shape of the graph was influenced by the size factor, there being a tendency for both very high-protein and very low-protein samples to be sub-normal in size. When the hardness factors were substituted for strain in the graph, very irregular lines resulted. However, a curved relationship which may be significant was found between the per cent. vitreous kernels and the per cent. protein content This is shown in Figure 2, a scatter diagram, containing in addition the line of mean percentages vit-

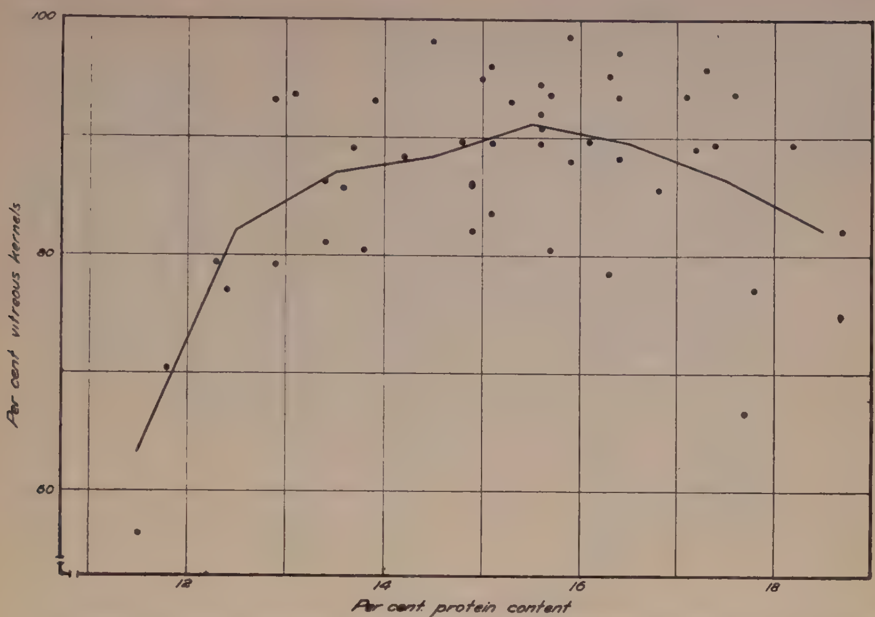

FIGURE 2.—Scatter diagram of relation between vitreous kernels and protein content, with line of mean percentages vitreous kernels.

reous kernels related to given protein contents. Evidently factors other than protein content play a part in determinating the texture of the kernels.

Confirmation of this point is afforded by the data presented in Table 5. These are the results obtained in a special study of the hardness and protein content of vitreous and starchy kernels from the same sample. Of the 49 samples used in the general investigation, only 16 contained a percentage of starchy kernels high enough to make the separation of the required number reasonably possible. To keep the labour within bounds, the number of kernels cracked was reduced to 100 vitreous and 100 starchy from each sample. Reference to Table 1 will show that the probable error in cracking strain was small even for this number. No piebald kernels were used.

The results show that in all cases but one the vitreous kernels are higher than the starchy kernels in protein content. Again with one exception, the vitreous kernels are the harder. The variations in hardness and protein content between the vitreous and starchy kernels of a given sample, however, are matched, or indeed frequently exceeded, by variations in an opposite direction between the vitreous and starchy kernels of different samples. This explains why the correlations of hardness factor *a* and protein content for these 16 samples gives a coefficient of only 0.32 ± 0.11, and helps to explain further the failure to demonstrate similar relationships in the larger series previously discussed.

It must be concluded that a relation between hardness and protein content exists only within a given sample, in which other factors of difference are ruled out. The same conclusion must be reached in regard to vitreousness and protein content, in so far at least as a linear relationship

TABLE 5.—*Hardness and protein content of vitreous and starchy kernels.*

Variety	Station and year	Texture of kernels	Av. diam.	Av. strain	Hardness factor a (Strain / diam.)	Protein content
			mm.	kg.		%
Red Fife	Leth. (dry)† 1924	Vitreous	2.57	3.74	1.46	18.3
		Starchy	2.61	3.52	1.35	17.9
	Leth. (irr.)‡ 1924	Vitreous	2.69	4.78	1.78	15.3
		Starchy	2.70	4.62	1.71	14.7
	Brooks (irr.) 1924	Vitreous	2.55	4.07	1.60	12.8
		Starchy	2.72	3.97	1.45	10.8
	Edmonton 1923	Vitreous	2.69	4.55	1.69	15.9
		Starchy	2.68	3.87	1.44	12.7
	Beaverlodge 1924	Vitreous	2.58	4.25	1.65	18.1
		Starchy	2.67	4.11	1.54	17.3
	Ft. Vermilion 1924	Vitreous	2.71	4.03	1.49	15.0
		Starchy	2.79	3.84	1.38	11.5
Renfrew	Brooks (irr.) 1924	Vitreous	2.53	4.60	1.82	12.7
		Starchy	2.69	4.47	1.66	10.8
	Ft. Vermilion 1924	Vitreous	3.04	4.82	1.58	13.5
		Starchy	3.04	4.61	1.52	11.2
Marquis	Brooks (irr.) 1924	Vitreous	2.78	4.40	1.58	13.7
		Starchy	2.73	4.05	1.48	11.1
	Edmonton 1923	Vitreous	2.74	4.24	1.55	14.5
		Starchy	2.70	4.05	1.50	10.4
	Beaverlodge 1924	Vitreous	2.60	4.61	1.77	17.6
		Starchy	2.60	4.19	1.61	17.2
	Ft. Vermilion 1924	Vitreous	2.92	4.37	1.50	15.3
		Starchy	2.94	4.65	1.58*	11.4
Ruby	Brooks (irr.) 1924	Vitreous	2.42	4.30	1.78	13.8
		Starchy	2.57	3.51	1.36	12.1
	Beaverlodge 1924	Vitreous	2.40	4.57	1.90	18.0
		Starchy	2.39	4.36	1.82	16.9
Kubanka	Brooks (irr.) 1924	Vitreous	2.62	5.12	1.95	12.6
		Starchy	2.61	4.33	1.66	9.7
	Beaverlodge 1924	Vitreous	2.78	7.01	2.52	16.9
		Starchy	2.63	5.71	2.17	17.3*

†‡ Dry land and irrigated wheat respectively.
* Exceptions noted in text.

is concerned. The factors which disturb the relationship do not seem to depend upon inherent differences between varieties, since there is no greater consistency observable in a series of samples of one variety grown under different conditions than between samples of different varieties. Apparently the conditions of growth, modifying the development of the kernel and the manner in which various constituents are laid down, influence kernel texture, hardness and protein content somewhat independently.

Evidently the relation between hardness and protein content is too complicated to give promise of much practical utility in wheat grading. The point must not be overlooked, however, that apart from possible differences in protein content, vitreous kernels possess a higher milling value than starchy kernels, because of their physical properties.

Supplementary Experiments on Moisture Content and Hardness.

In the foregoing investigation it was assumed that during a month's storage over a potassium hydroxide solution of definite concentration in

TABLE 6.—*Moisture content of wheat samples of various protein contents, at relative humidity of about 71 per cent.*

Sample	Protein content	Initial moisture content	Moisture content after storage
	%	%	%
Lot A—Stored a month over KOH solution (40 g. in 100 g. H_2O).			
Renfrew (Brooks, 1924)	12.4	7.4	13.5
Kubanka (Edmonton, 1923)	15.9	6.0	11.1
Ruby (Fort Vermilion, 1924)	15.9	7.8	12.7
Marquis (Leth., dry land, 1924)	17.3	6.7	12.8
Marquis (Edmonton, 1923)	14.8	6.0	12.6
Lot B—Stored 134 days over KOH solution.			
Huron (Fort Vermilion, 1924)	15.6	8.2	10.9
Red Fife (Vancouver, 1924)	13.1	6.8	11.2
Marquis (Vancouver, 1924)	13.7	6.7	10.9
Marquis (Edmonton, 1924)	16.4	6.8	11.3
Kubanka (Leth., irrigated, 1924)	15.6	6.6	10.9

a closed vessel, all samples would reach within narrow limits the same moisture content. This assumption was borne out by the work of Coleman and Fellows (*2*). However, towards the end of the work, in the winter of 1924-25, moisture determinations on the residues of a few samples showed that considerable variation occurred. These results are given in Table 6 (Lot A). The residues of other samples were then allowed to remain in storage for a period of 134 days, after which they were found to have a lower though more constant moisture content (Lot B).

The only change known to have taken place in the experimental conditions under which the two lots of samples were kept was a drop of a few degrees in the average room temperature, consequent on the discontinuance of steam heating with the advent of spring. This, however, with the potassium hydroxide solution used would have the effect of increasing slightly (less than 0.5 per cent) the relative humidity of the atmosphere within the storage vessel. Since in addition the hydration of colloidal material is normally greater at lower temperatures, on theoretical grounds an increase rather than a decrease in the moisture content of the kernels would have been expected. The direction of the change cannot, therefore, be explained at present.

The protein percentages of the samples concerned are also given in the table, but there is no evident relation between these values and the percentages of moisture.

The discovery of these unexpectedly large variations in moisture content led to further experiments to ascertain their possible effect on the hardness of the kernels. Two varieties of wheat, differing widely in protein content, were cracked at a graduated series of moisture contents. The varieties were Marquis and Standup, the former being a well-developed vitreous sample grown in Alberta, and the latter a plump starchy sample grown in England. These samples contained respectively 18.2 and 10.2 per cent protein.

The samples were subjected to six humidity conditions, varying from zero to 86 per cent. They were placed first in two desiccators, containing respectively concentrated sulphuric acid (95.5%) and potassium hydroxide (40 g. KOH : 60 cc. H_2O). Three weeks later the air was exhausted from the sulphuric acid desiccator, and the concentration of the potassium hydroxide reduced (40 : 100). About three months later the residues of

the samples over sulphuric acid were oven-dried, while the humidity in the other desiccator was still further increased by replacing the potassium hydroxide solution with a saturated solution of potassium bromide (R.H. 86%). This treatment brought about a gradual change in moisture content of the samples in both directions from the original air-dry condition (about 8%). The solutions in the desiccators were changed more frequently than indicated above, in order to maintain approximately the original concentrations.

At intervals during the foregoing treatment, sub-samples of 200 kernels of each variety were cracked, the moisture content at the time of sampling being determined in every instance. It is of interest to record that the Standup variety, with the larger starchy kernels, required in all cases a higher cracking strain. When, however, the data are expressed in terms of hardness factor *a*, the relationship, except at the highest moisture contents, is reversed, the smaller but more vitreous kernels of Marquis showing greater hardness.

The results of the experiment are shown graphically in Figure 3, in which the values of hardness factor *a* are plotted against the percentages of moisture contained in the samples at the time of cracking. It would appear from this figure that there is little difference in the hardness factor between the limits of 2 and 11 per cent moisture. In the oven-dry condition the hardness is slightly lower, but the relative difference between the two varieties is as great here as on any part of the curve. There is thus on the basis of this experiment no real criticism to be made of the oven-drying method, as used by Roberts (7). Above 11 per cent. moisture the hardness factor again decreases, falling off more rapidly in the high-protein variety. Possibly vitreous kernels, having a more gel-like structure, are more affected in their physical properties by small additions of water at this critical point.

It will be seen in the figure that the hardness lines of the two varieties intersect at 12 per cent moisture. It seems doubtful, however, that high-

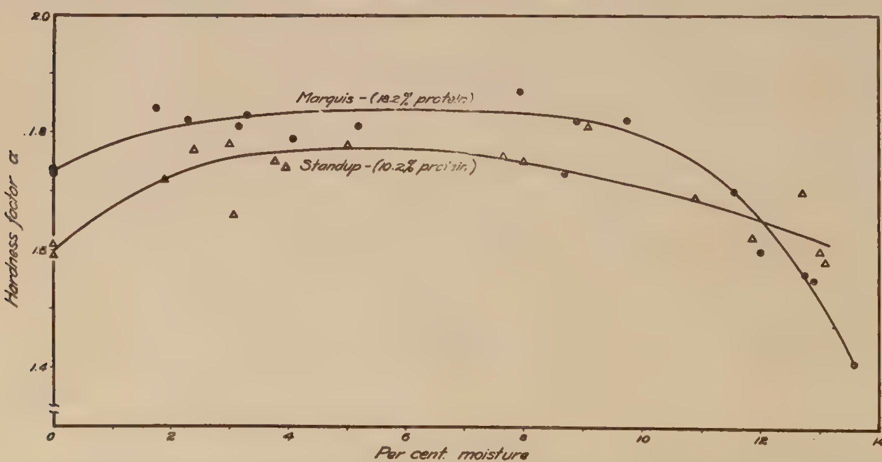

FIGURE 3.—Relation of hardness to moisture content of kernels, in two varieties differing widely in protein content.

protein wheat would generally be found as soft as low-protein wheat at this moisture content, since on referring back to Table 5 it will be seen that within a given sample the higher protein kernels were almost without exception harder than starchy kernels. The conditions of the latter experiment were such that the kernels would be expected to have contained about 12 per cent moisture. However, not sufficient data on moisture contents were obtained to settle the point. Evidently it would be desirable in future work on hardness to select a moisture content well within the flat portion of the curves.

Summary.

1. A machine has been devised for cracking wheat kernels transversely, which gives a quantitative measurement of hardness both accurately and conveniently.
2. The size of kernel, expressed either as diameter or volume, has been shown by linear correlation to have a marked effect on the cracking strain. This effect has been largely eliminated by expressing hardness as strain per millimeter of diameter.
3. Within a given sample, the vitreous kernels are harder and contain more protein than the starchy kernels. Over a series of samples, however, it has been impossible to demonstrate a linear correlation between hardness and protein content. This is in harmony with the results of previous investigators. The disturbing factors do not appear to lie in inherent differences between varieties, but seem rather to be environmental effects.
4. Some evidence of a curved relationship between per cent vitreous kernels and protein content was obtained.
5. The moisture content of the kernels of two varieties differing widely in protein content had little effect on their hardness over a range of 2 to 11 per cent. Beyond this range there was a tendency for hardness to diminish.

University of Alberta,
Edmonton, Alberta.

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THE INFLUENCE OF CERTAIN ENVIRONMENTAL FACTORS ON THE DEVELOPMENT OF BACON HOGS.

R. D. Sinclair and J. P. Sackville.

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The influence exerted by various environmental factors during the development period of an animal's history has been regarded as playing a very important part in determining the ultimate type. Certain factions in draft horse breeding circles hold the view that such factors as the amount and quality of the ration fed and exercise allowed during the growing stage have an important bearing on the type and quality of the mature drafter. Breeders of dairy cattle are of the opinion that dairy characteristics and general refinement in the highest degree in the mature cow are only possible when due attention is given to proper rationing of the growing heifer. This matter has probably been given more consideration in recent years by producers of bacon hogs than by the breeders of other classes of livestock. It has been considered that, while a certain programme of feeding and management methods would result in a marketable hog conforming to the highest standard, certain other programmes would lead to the development of a type of hog which would fall short of the requirement of our most discriminating market.

To state the problem definitely as it applies to bacon hog production, the view was held that limited rationing during the initial and intermediate stages of growth, followed by a finishing period, would result in a hog of greater length and showing more desirable general type and finish than the individual which was heavily rationed from weaning time to market weight. From the standpoint of the producer the problem was limited rationing and a long feeding period, or comparatively heavy feeding and a shorter feeding period with a smaller labor investment. Similarly the matter of rations, with special reference to protein supplements, was felt to have a bearing on the production of bacon hogs of the most desirable type and quality. In the older bacon hog producing areas the development of this type was intimately associated with the dairy industry and dairy by-products were closely linked up with bacon hog rations. In the newer areas, the introduction of the bacon hog as Canada's national type brought about a realization that its wholesale reception might be hampered on account of the scarcity of dairy by-products. The problem then arose as to whether such a packing house by-product as tankage could be substituted for skim-milk and ensure as desirable a hog and resultant product. The other alternative was the use of a ration consisting of farm grown grains without the use of any supplementary feed. In addition to these questions, the influence of succulent pasture crops and unlimited exercise in the feeding and management schedule was open for consideration. It was generally regarded that the use of forage crops would result in the development of a hog of greater length and showing a more desirable trimness of outline than the hog confined to dry lot and with exercise reduced to a minimum.

With these problems in mind a three year experimental project was outlined at the University of Alberta in 1923. The objects of the three experiments conducted during the years 1923-24-25 were:—(1) to compare self-feeding and limited hand-feeding with respect to the type of hog and quality of carcass produced, (2) to compare skim-milk and tankage as protein supplements for the bacon hog and, in addition, to determine the suitability of a non-supplemented home grown ration from the standpoint of producing a hog of the most desirable type, (3) to compare pasture management with dry lot management in relation to the ultimate type developed and (4) to study the relative importance of feeding and breeding in the development of bacon type.

Before proceeding with an outline of the methods of the experiments and a discussion of the results, it may be well to draw attention to other work of a similar nature and some of the results reported.

Review of Literature.

Reed (*1*) in reporting two tests conducted during the summer of 1923 gives a verdict in favor of hand-feeding for bacon hog production. Referring to the type of hog produced he states that "the self-fed pigs developed a much fatter carcass and a shorter side of bacon. They were chunkier, smoother hogs. The hand-fed hogs were fat enough for killing purposes and had a more even thickness of fat, averaging one-fourth of an inch less in depth along the back. They developed more bone and muscle in proportion to fat which is desirable in the select bacon hog. None of the self-fed hogs graded select bacon, but three hand-fed hogs made the select grade." Summarizing the results of the two experiments Reed says, "The self-feeder develops a short, thickly fleshed hog which goes to market earlier but is too short and thick to grade select bacon."

Dunsmore (*2*) reports that in comparing self-feeding, full hand-feeding and limited hand-feeding, under dry lot conditions, the only hogs which approached the select bacon type were those in the light hand-fed lot, three of the hogs in this lot grading as "select." The self-fed hogs in this test all graded as "thick smooth" while the heavy hand-fed hogs also graded "thick smooth." He states further that a test conducted at the Dominion Experimental Station at Rosthern, Saskatchewan, showed that self-fed hogs showed greater uniformity than hand-fed hogs, but hand-fed hogs were heavier and more nearly approached the desired bacon type.

In reporting an experiment conducted at the Central Experimental Farm, Rothwell (*3*) states that self-feeding did not give as good results as hand-feeding from the standpoint of the carcass produced. The self-fed hogs did not dress into desirable carcasses for bacon purposes, these being somewhat shorter in length of side and carrying an excess of fat in proportion to lean meat. He concludes that for the production of the most desirable bacon carcasses the free choice system is not satisfactory, more particularly where corn is supplied.

Referring to the influence which various feeds exert on the pig during the weaning period and from weaning until the pigs reach twelve weeks of

age, Rothwell (*4*) states that three years' work of an experimental nature at the Central Experimental Farm revealed conclusively that:— (1) young pigs fed rations containing a minimum of fiber and with skim-milk available had little or no setback following weaning and grew the frame and bone that enabled them later to grow into select bacon hogs, (2) weanling pigs fed the same ration without skim-milk were much less thrifty, inclined to be stunted and developed into slower finishing and thicker, shorter hogs. and (3) pigs fed meal and tankage (no milk), while not of the undesirable type of the hogs getting meal only, were nevertheless sufficiently checked in growth to cause their development into market pigs too short, too thick, and lacking quality.

Tinline (*5*) reports an experiment which indicated that while pigs fed through the self-feeder were ready for market three weeks before those that were hand-fed, they were short bodied, shop hogs, while the trough-fed lot conformed more closely to the bacon type.

Wood (*6*) is of the opinion that forced feeding during the early stages of growth prevents development and length of side and tends to produce market pigs of the thick smooth class. This opinion is based on the results of an experiment conducted at the Manitoba Agricultural College during the year 1923. He further found that the addition of tankage to a ration of farm grown grains "stimulated growth and had a marked effect on the type of pig produced." The addition of skim-milk to the ration of farm grown grains had a similar but less marked effect.

In reporting the results of a trial with grade Yorkshire feeder pigs purchased in Canada, Fargo (*7*) states that a carcass test failed to show any noticeable difference between Wiltshire sides produced from self-fed and hand-fed hogs. He is not so sure that this result might have been secured had the pigs been started on experiment at a weight of fifty pounds.

Joseph (*8*) in commenting on the results of an experiment in which pigs were fed protein allowances varying from 0.32 to 0.94 pounds per hundred pounds of live weight, with a view to determining the effect of these allowances on the quantity and distribution of the protein, states that there did not appear to be any indication that the amount of protein consumed exerted any influence upon the distribution of nitrogen in the fat. That the amount of protein fed may influence the amount of body protein is suggested in his concluding remark,—"when the supply of protein is deficient either quantitatively or qualitatively it seems that the amount of body protein is affected while the character of the proteins formed in the various tissues remains unchanged."

A problem closely related to those under consideration, but dealing with dairy cattle is reported by Eckles (*9*). In discussing the effect of rations on the growing dairy heifer with respect to ultimate type, he states that the heifers receiving the heavy rations showed a coarseness of bone not found in those receiving a lighter ration. This appearance was easily apparent to the observer, but was difficult to show in any form of measurements. The coarseness was most apparent in the head. He states that the general conclusions to be drawn from the experiment records and

observations are that the character of the ration during the growing period undoubtedly is a factor having some influence on dairy type. A ration giving an abundance of nutrients in an easily digested form results in more rapid growth and a tendency to coarseness of bone and body.

Methods of the Experiments

Space will not permit of a detailed discussion of all of the conditions of the individual experiments. It is sufficient to say that feeding and management methods were uniform in the three trials and the method of allotment was such as would insure as nearly as possible uniform breeding in the various experimental groups. In making a distribution of pigs in the eight experimental groups, litters of eight or more uniform pigs were selected and a pig from each litter was placed in each experimental group. In this way genetic differences were as nearly as possible overcome and the various lots were placed on a nearly uniform basis in the matter of "potentialities." Pigs were weaned at eight weeks of age and placed on their respective rations immediately after weaning. The following tabulation will serve to outline the experimental groups.

Lot I	Grain, skim-milk, self feeder, pasture.
Lot II	Grain, skim-milk, limited hand-fed, pasture.
Lot III	Grain, skim-milk, self-feeder, dry lot.
Lot IV	Grain, skim-milk, limited hand-fed, dry lot.
Lot V	Grain, Tankage 10%, self-feeder, pasture.
Lot VI	Grain, Tankage 10%, limited hand-fed, pasture.
Lot VII	Grain, no supplement, self-feeder, pasture.
Lot VIII	Grain, no supplement, limited hand-fed, pasture.

This method of arrangement made provision for a quadruplicate check on the self-feeding and limited hand-feeding comparison, a duplicate check on the skim-milk, tankage and no supplement comparison and a duplicate check on the pasture and dry-lot comparisons.

All pigs used in these experiments were bred on the University of Alberta Farm. In Experiment I (1923) 56 pigs were used. Of this number 24 were purebred Tamworths, 16 were purebred Berkshires and 8 were Tamworth-Berkshire crossbreds, while 8 were Berkshire-Poland China crossbreds. In Experiment II (1924) 56 pigs were used. This number included 8 purebred Tamworths, 8 Yorkshire-Tamworth crossbreds, 16 Yorkshire-Berkshire crossbreds, 8 Duroc Jersey-Tamworth crossbreds, and 16 Yorkshire-Poland China crossbreds. Experiment III (1925) involved the use of 64 pigs. The breeding represented was as follows: 24 purebred Tamworths, 24 Yorkshire-Tamworth crossbreds, 16 purebred Berkshires. In selecting pigs for these experiments it was not deemed necessary to confine the selection to pigs of strictly bacon breeding. It was thought that differences in the finished pig due to the influence of various rations and methods of feeding would be as apparent, or even more apparent, in the case of the shorter, thicker pig than in the case of the pig of bacon propensities.

The hogs were removed from the experiments at a final weight of approximately two hundred pounds and were graded before slaughter by the

Dominion Government Grader stationed at the Edmonton Stockyards. He rendered an unbiased judgment as to which of the hogs showed the proper type and finish to grade as "select" bacon.

The hogs were slaughtered at one of the local abbatoirs. Dressing percentage was based on the warm dressed weight, head on and leaf lard in, and the final live weight off experiment. After slaughter the individual carcasses were scored by parties familiar with the requirements of the bacon trade, and in connection with the scoring process the official "Score Card for Canadian Wiltshire Sides" was used. In view of the complete weights and measurements involved in the scoring process it might be said that an effort was made to apply "Babcock" methods in studying the Wiltshire sides produced by the various rations and methods of feeding.

Results of the Experiments.

No attempt will be made to present the results of the individual experiments. Space will not permit and since the methods in the three experiments have been uniform it would seem that the averaging of the figures for the three trials would provide a satisfactory basis for a reliable and more definite interpretation of results. Small differences on the basis of an average of the three experiments would be more significant than in a single experiment and averaging the three experiments would tend to harmonize some of the more inconsistent features and bring them into form for interpretation. Rather than present the results in one table several tables will be presented with a view to setting out more clearly the results in connection with the various problems under consideration.

Comparison of Self-feeding and Hand-feeding.

The results of the comparison of self-feeding and hand-feeding are shown in Table 1. In order to bring together all the evidence that these experiments are capable of yielding on this problem, all of the self-fed groups on the various rations have been brought together and likewise all of the limited hand-fed groups.

Table 1.—*Comparison of self-feeding and hand-feeding.*

	Self-Fed Lots 1-3-5-7-	Hand-Fed Lots 2-4-6-8-
Number of Pigs	80	79
Number of Selects	28	27
Percentage of Selects	35.0	34.18
Number of Wiltshires of "leanest" and "lean" grades	56	49
Percentage of Wiltshires	70	62
Ave. dressing percentage	75.6	74.9
Ave. length of Carcass	28.42	28.47
Ave. Score on Carcass	83.88	83.32
Ave. Score on Carcass Quality	80.0	79.5

It will be noted that a slightly higher percentage of selects was produced in the self-fed lots than in the hand-fed groups. The difference is very small, however, and it can scarcely be said that one method of feeding has given better results than another in this connection. Any difference in

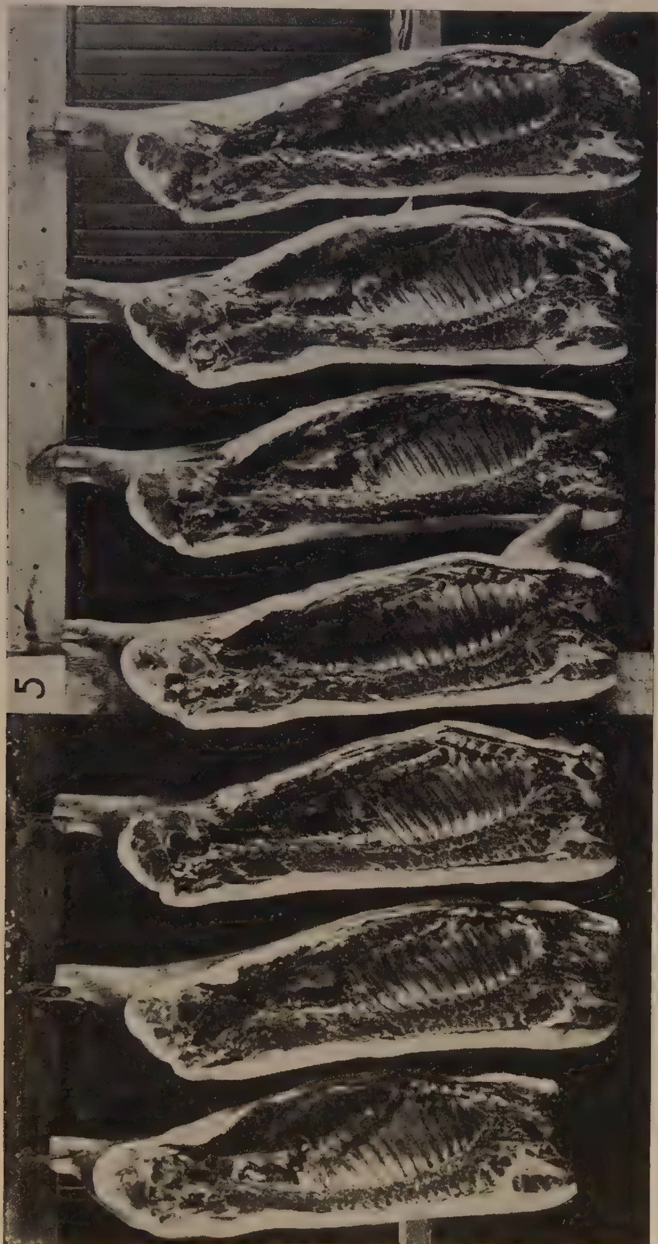

Figure 1. Group of Wiltshire sides from Lot V in Experiment III (Tankage-Pasture-Self-feeder). Four "leanest" Wiltshires and three "lean" Wiltshires averaged 29 inches in length.

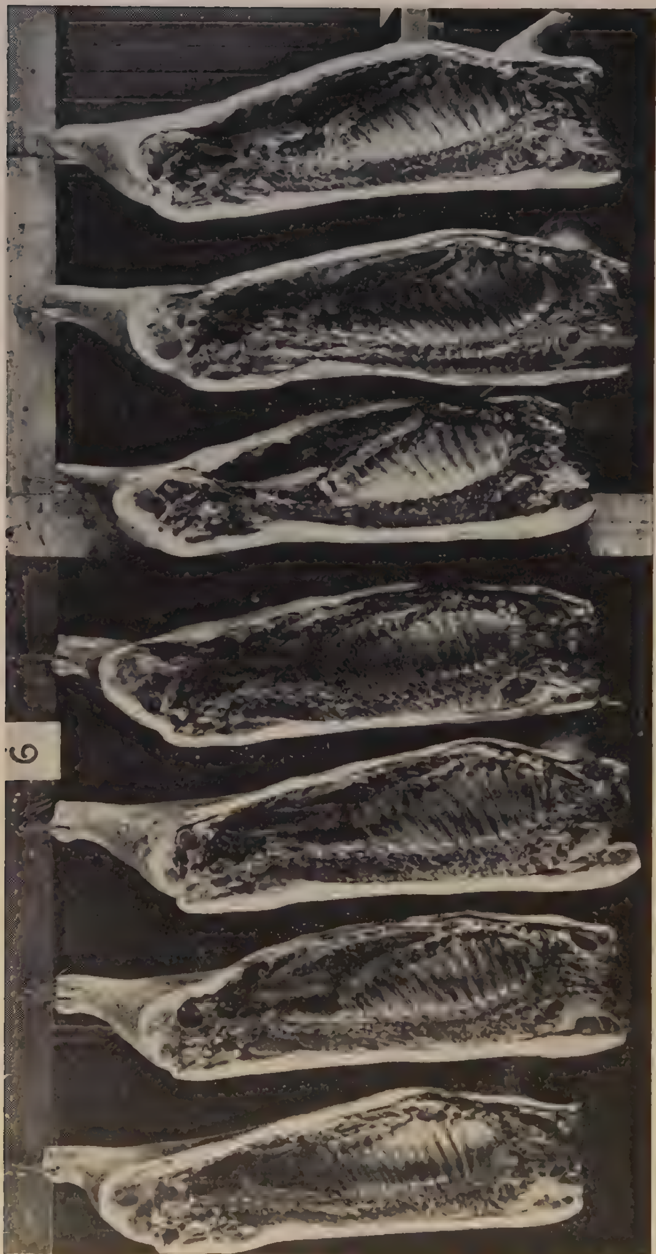

FIGURE 2. Group of Wiltshire sides from Lot VI in Experiment III (Tankage-Pasture-Hand-fed). Three "leanest" and two "lean" Wiltshires were graded out of this group. Average length of carcasses, 28.4 inches. Note the tendency toward a lack of finish as compared with carcasses shown in Fig. 1.

favor of the self-fed groups would be mainly due to better finish at market weight. In connection with the comparative types of the two groups of pigs it may be mentioned that observations made on the various groups during the progress of the experiments, as well as photographic studies, indicated a tendency toward more of the bacon type during the initial and intermediate stages of growth in the case of the hand-fed lots, but as the pigs advanced in stage of maturity and degree of finish no obvious differences could be noted in the general type developed by the two methods of feeding The self-fed pigs were found to yield a carcass with a firmer, thicker belly, the average thickness of belly being 1.54 inches in the self-fed carcasses and 1.40 inches in those hand-fed.

The self-fed groups yielded 8 per cent more suitable Wiltshires than the hand-fed groups. The main factor affecting the difference in the number of Wiltshires in the two groups was the number of carcasses in the hand-fed groups which could not be rated as acceptable on account of lack of fat covering and thin middles. In this connection it is worth recalling that a greater percentage of "leanest" Wiltshires was produced by hand-feeding. Of the Wiltshires located in the self-fed lots 50 per cent were "leanest," while in the hand-fed groups 72 per cent were of this grade.

The average length of carcasses in the hand-fed lots was .05 inches greater than in the self-fed lots. The difference can hardly be regarded as significant. Obviously no difference could be detected by the naked eye in the live animals.

The average score on the entire carcass indicates that there is very little difference in the two methods of feeding so far as the conformation and quality of the carcass is concerned. In some instances self-feeding led to a slightly higher carcass score while in other cases hand-feeding led to a higher score, but in no case was the difference more than 1.5 per cent of the total score. The slightly higher score shown in the table in favor of self-feeding is in keeping with the higher percentage of Wiltshires indicated.

A Comparison of Skim-milk and Tankage.

Table 2 shows the results of the live and carcass grading in the groups fed skim-milk as compared with tankage, these groups being compared with the pigs receiving no protein supplement.

Table 2.—*Comparison of skim-milk and tankage.*

	Skim-milk (Lots 1-2)	Tankage (Lots 5-6)	No Supplement (Lots 7-8)
Number of pigs	40	41	40
Number of selects	14	17	11
Percentage of selects	35	41.5	27.5
Number of "leanest" and "lean" Wiltshires	29	26	24
Percentage of Wiltshires	72.5	63.4	60
Ave. Dressing Percentage	75.6	75.5	76.3
Ave. Length of Carcass	28.31	28.46	28.53
Ave. Score on Carcass	83.7	83.9	81.98
Ave. Score on Carcass Quality	80.8	80.4	76.5

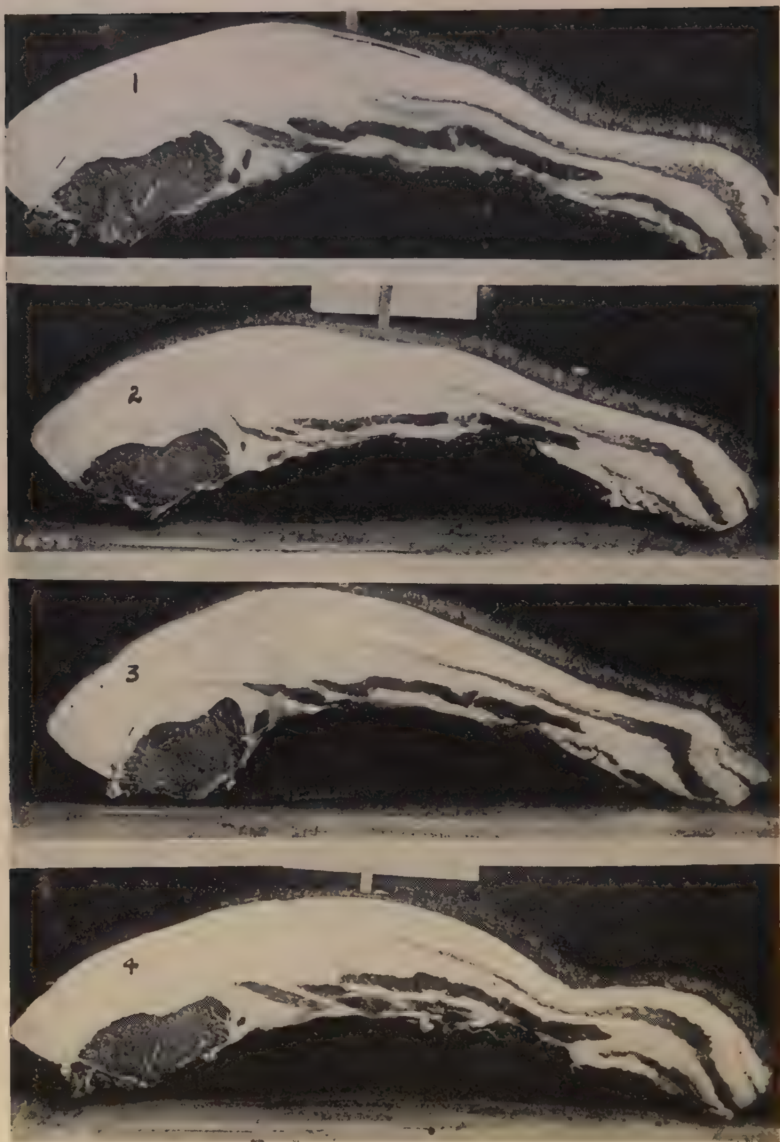

FIGURE 3. Cross-section views showing development of "eye of lean" and mixture of fat and lean in "streak", in litter mate carcasses from Lots 1, 2, 3, 4 (top to bottom), in Experiment III.

On the strength of the foregoing data a statement may be made that a higher percentage of selects was graded out of the tankage groups than out of the skim-milk lots. So far as the general type of the hogs in the two groups is concerned, no apparent difference could be noticed when they reached market weight. A smaller percentage of selects was secured out of the groups fed grain alone than from those where a protein supplement was fed. It was apparent that pigs deprived of a protein supplement

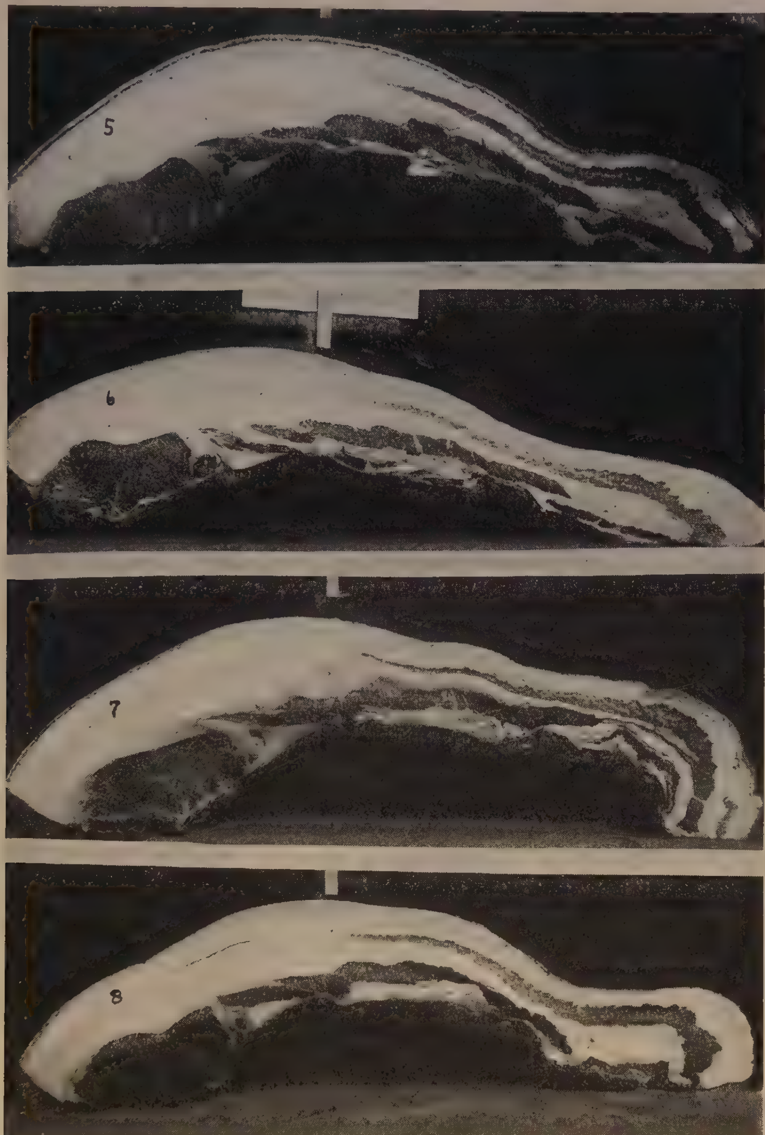

FIGURE 4. Cross-section views showing development of "eye of lean" and mixture of fat and lean in "streak" in litter mate carcasses from Lots 5, 6, 7, 8 (top to bottom), in Experiment III.

lacked somewhat in finish when of acceptable weights and showed a tendency to coarseness of hair and bone and excessive paunchiness. It would seem that slow growth and an apparent lack of thrift are not consistent with the development of the best type in bacon hogs.

The pigs on the skim-milk ration yielded a higher percentage of suitable Wiltshires than those fed tankage. This result cannot be attributed to any particular feature of superiority among the carcasses yielded by the

Figure 5. Yorkshire-Tamworth crossbred pig out of Lot I, Experiment III (Skim-milk-Pasture-Self-feeder). A very smooth, trim, well-finished pig grading "select" at a final weight of 195 lbs. on Sept. 23, 1925.

Figure 6. Yorkshire-Tamworth crossbred pig out of Lot V, Experiment III (tankage-Pasture-Self-feeder). Litter mate of pig shown in Fig. 5. A neat, well-finished pig which graded "select" at a final weight of 193 lbs. on Oct. 14, 1925. There was little to choose between these two pigs in general trimness, type and finish.

skim-milk groups, but rather to the accumulative effect of minor details. It may be mentioned here that while other groups yielded some carcasses that could be classified as "soft" none was found in the skim-milk lots. The pigs fed the "grain alone" ration yielded a lower percentage of Wiltshires than those fed the supplement rations. Lack of fat covering was the main factor in reducing the percentage of Wiltshires in the "grain alone" groups.

While there was some difference in the average length of carcasses yielded by pigs on the various rations it is doubtful if this can be regarded as significant from the standpoint of influencing length by feeding. The Wiltshire sides from the pigs on the "grain alone" ration were .07 inches longer than those fed tankage and .22 inches longer than those fed skim-

FIGURE 7. Yorkshire-Tamworth crossbred pig out of Lot VII, Experiment III (No-supplement-Pasture-Self-feeder). Litter mate of pigs shown in Figs. 5 and 6. A pig of good length, graded "select" at a final weight of 202 lbs. on Jan. 6th, 1926, but showing a tendency towards paunchiness and coarseness of hair and bone.

milk. The difference in length between the grain alone and skim-milk group would suggest that there may be some relation between rate of growth and body length, but only to a very limited degree.

From the standpoint of carcass quality a slight superiority in the skim-milk groups is indicated. The main difference was to be found in a tendency toward a more uniformly firm fat in the case of the skim-milk fed pigs. On the whole, the proportion of fat and lean was found to be rather more desirable in the tankage-fed carcasses than in those developed by skim-milk feeding, as indicated by a higher score on the two features:— development of eye of lean in loin and mixture of fat and lean in streak. The lowest score in these features was given to the "grain alone" carcasses. The percentage of lean would therefore appear to be more or less related to the nutritive ratio of the ration fed, being on the average during the feeding period 1:4.2 in the tankage groups, 1:4.6 in the skim-milk groups and 1:6.9 in the "no supplement" lots.

COMPARISON OF PASTURE AND DRY LOT FEEDING.

The results of the experiments from the standpoint of the relative merits of pasture and dry lot management are presented in Table 3.

TABLE 3.—*Comparison of pasture and dry lot.*

	Pasture (Lots 1-2)	Dry Lot (Lots 3-4)
Number of pigs	40	38
Number of Selects	14	13
Percentage of Selects	35	34.2
Number of "Leanest" and "Lean" Wiltshires	29	26
Percentage of Wiltshires	72.5	68.4
Ave. Dressing Percentage	75.6	73.65
Ave. Length of Carcass	28.31	28.55
Ave. Score on Carcass	83.7	84.8
Ave. Score on Carcass Quality	80.8	81.2

FIGURE 8. Group of self-fed pigs—Lot I, Experiment III (Skim-milk-Pasture-Self-feeder). Marketed on the average of 118 days after weaning. Av. daily gain, 1.39 lbs. Five out of seven graded "select".

The very close results in the matter of selects graded out of the two groups indicate that there was very little difference in the type of the pigs developed by the two methods of feeding. It is well to have in mind here of course that skim-milk was fairly liberally fed in both pasture and dry lot groups.

The difference in percentage of Wiltshires in the two groups is in favor of pasture feeding, although the difference is not marked. In connection with this feature it seems worth mentioning that a higher percentage of "leanest" Wiltshires was found in the dry lots than in the pasture-fed groups.

The carcasses yielded by the dry lot pigs measured on the average .24 inches longer than those fed on pasture. This result indicates that under the condition of these experiments the use of pasture and unlimited exercise were not conducive to the development of greater length of body.

The average score on the carcasses suggests a slight superiority in the case of those produced by the dry lot feeding. It was noted that there was a slightly better development of "eye of lean" in the dry lot carcasses, but in other respects there was little to choose between the two groups.

SUMMARY.

Self-feeding gave satisfactory results in the development of pigs of "select" grade. A higher percentage of selects and a larger number of suitable Wiltshires were graded out of the self-fed groups indicating that the self-feeder, under the conditions existing is these trials, did not lead to too early maturity and the development of a short thick pig. It would appear that where the labor factor makes it advisable to consider the use of the self-feeder, there is reasonable assurance that the type of pig will not suffer by comparison with the type produced by a similar ration limited hand-fed.

The fact that a higher percentage of selects was graded out of the groups fed tankage than out of the groups fed skim-milk indicates that a

lack of skim-milk need not be regarded as a serious limiting factor in developing the bacon type of pig. Pigs fed tankage developed satisfactorily from weaning time and at market weight showed a type and finish which did not suffer by comparison with those fed skim-milk. While the quality of the carcasses yielded by the skim-milk lots tended to be rather better than in the tankage lots, the difference was slight and on the whole the Wiltshire sides produced by tankage feeding were very acceptable. The feeding of a non-supplemented grain ration did not lead to the development of pigs with the desired type and finish. The comparatively slow growth of the pigs in these groups gave rise to a coarseness of bone and heaviness of middle and at reasonable bacon weights many of these pigs lacked necessary finish.

The pigs produced under pasture conditions had very little advantage over those developed in the dry lots in these experiments. It would appear that when skim-milk is available in generous quantities the addition of a pasture crop to the ration does not aid materially in developing the desired type nor in contributing to improvement in the quality of the carcass. The unrestricted exercise accompanying the use of pasture was not reflected in greater "stretch" in the pigs at market weight nor in greater length by tapeline measurement of the carcass.

Conclusions.

1. Self-feeding gave better results in the development of the select bacon type than limited hand-feeding, and gave rise to the production of a higher percentage of desirable Wiltshire sides.
2. Self-fed pigs, during the feeding period, tend to show more middle than limited hand-fed pigs, but when shrunk will invariably conform to the bacon standard in underline and will tend to yield a carcass with a thicker, firmer belly.
3. Tankage produced a higher percentage of selects than skim-milk, but examination of the carcasses showed a higher percentage of suitable Wiltshires in the skim-milk fed groups.
4. Due mainly to a lack of condition a lower percentage of selects and fewer suitable Wiltshires were yielded by the groups fed the non-supplemented grain ration. The pigs in these lots developed a coarseness of hair and bone and a tendency to excessive paunchiness.
5. Under the conditions of these experiments there appeared to be little difference between pasture and dry lot management with regard to the influence on the type of hog and quality of carcass produced.
6. Exercise does not appear to be a factor promoting greater length of carcass.
7. Carcass dimensions in general were not modified to any significant degree by any particular ration or method of feeding.

University of Alberta,
Edmonton, Alta.

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EASTERN CANADA SOCIETY OF ANIMAL PRODUCTION

Executive Meeting

A meeting of the executive of the Eastern Canada Society of Animal Production, together with the chairmen of the various standing committees, was held recently in Montreal. The following were present: Prof. Wade Toole, O.A.C., Guelph, President and Chairman of Beef Cattle Committee; Dean H. Barton, Macdonald College, P.Q., Vice-President; S. E. Todd, Toronto, Ont., Ontario Director; Stéphane Boily, Sherbrooke, Que., Quebec Director; Jas. Bremner, Fredericton, N.B., Maritime Director; G. B. Rothwell, Dominion Experimental Farms, Ottawa, Chairman of Swine Committee and L. C. McOuat, Ottawa, Secretary.

The progress made by the various standing committees was taken into consideration and it was felt that it would be impossible to hold a successful annual meeting this fall. Further consideration of the work of the Society led to a unanimous decision on the part of the executive to seek affiliation at once with the Canadian Society of Technical Agriculturists, in accordance with a resolution which was passed at the organization meeting last fall.

A special committee was appointed to meet with the executive of the Canadian Society of Technical Agriculturists to discuss with them terms of affiliation, and it is expected that arrangements will be made for a group or section of animal husbandmen within the larger Society.

In view of the decision it was deemed advisable to postpone the holding of an annual meeting until next June when it will be arranged to hold one with the annual convention of the Canadian Society of Technical Agriculturists, which is being held in Quebec City from June 11th to 14th inclusive.

The standing committees, which were appointed at the organization meeting last fall, have been reviewing their various fields of work and it is expected that they will have agreed upon certain specific problems of major importance upon which some definite work will have been completed by next June. Provision will be made in the convention programme for reports from these committees.

The executive hope that as many members as possible will plan to attend the meeting next June when matters of vital importance to the future of the society and its members will be discussed and decided upon.

L. C. McOuat.

BALANCING THE RATION

A Method of Determining the Composition of a Meal Mixture Suitable for a Given Purpose.

E. W. Crampton

[Received for publication October 15th, 1927.]

To compound a balanced ration, i.e., a day's feed for a given animal which contains exactly the right amounts of proteins, carbohydrates, and fat for the proper nutrition of that animal, is at best a complicated business. The hit and try method is the only way the final result can be obtained, and without some mathematical ability, a working knowledge of feedstuffs, and considerable patience, it becomes a task of no mean order, and one with which the majority of feeders will not be bothered.

On the other hand, there is ample proof that Feeding Standards are, on the average, correct in their stated requirements. There is also evidence that well fed animals are fed in accordance with these very standards, though perhaps often unwittingly.

The problem then would seem to be to devise some definite scheme, simple and rapid of operation, by which properly balanced rations may be put together, and which will at the same time be equally applicable to any and all classes of animals.

In studying this problem, the chief fault noted with the "balanced ration" (ration being used in the sense of 24 hours' feed for one animal) was in the fact that it is based on the requirement of a single animal for a single day. For example, one balanced ration for a cow weighing 1,200 lbs. and producing 30 lbs. of 3.5% milk consists of:

Timothy hay	10 lbs.
Corn silage	36 "
Barley meal	4 "
Wheat Bran	2½"
Linseed oilmeal	3¼"

Now there are two points on which this ration may be criticized from the point of view of the practical man. First, it does not represent actual feeding practice at all. The feeder does not mix feed for one cow. He mixes in quantities sufficient for several cows for several days. Accordingly, the first thing which he does is to translate the meal portion of his ration into terms of a meal mixture, which in this case might be,—

Corn Meal 400 lbs., Wheat Bran 250 lbs., and Linseed Oilmeal 325 lbs., and of such a mixture he will feed 9.75 lbs. to each cow in the same class as the one on whose requirements the ration was compounded.

The second point, and perhaps the more serious, is that the juggling of small amounts of feeds to balance the ration is a stumbling block mathematically to the whole scheme of scientific feeding, in so far as the farmer

is concerned. With the analysis of feedstuffs given on the basis of 100 lbs. of product, the determination of the absolute amounts of protein and total digestible nutrients in one-quarter of a pound is a puzzle to many of those most in need of assistance in their feeding practice, and a time consumer for the expert.

Why not eliminate both of these difficulties by dealing at the start with meal mixtures rather than with daily allowances? Such a plan would seem to have many advantages from the point of view of simplicity and efficiency. Accordingly the problem was attacked from this angle.

It was soon realized that the real determining factor in the question of what constituted a satisfactory meal mixture was the roughage allowance, or perhaps more properly, the feed other than meal, fed the animal in question. On the composition and quantity of this part of the ration hinges the amounts of protein and total digestible nutrients which must be supplied in the meal ration.

This leaves us three factors which must be determined before any move can be made regarding the meal mixture itself. They are:

(1) The daily requirements in Digestible Crude Protein and Total Digestible Nutrients of the animal in question. This information is obtained from the feeding standards.

(2) The amounts of Digestible Crude Protein (D.C.P.) and Total Digestible Nutrients (T.D.N.) supplied by the feed other than meal consumed daily by the animal.

(3) The amount of D.C.P. and T.D.N. which must be supplied in the meal allowance.

This is obtained from (1) and (2) by difference.

The question of finding the daily requirements of given animals from feeding standard tables brings up the question of calculation. Fortunately, however, these requirements are constant and therefore lend themselves to presentation in tables. Table 1 gives these data for most cases. From it, with the exception of daily cows in milk, the daily requirements of D.C.P. and T.D.N. may be read direct without calculation. In the case of dairy cows, the requirements for maintenance according to live weight must be added to those needed for milk production to get the complete figure.

To find the nutrition supplied by the "feed other than meal" is not quite as simple, for the combinations of materials used are many and various. In the majority of cases, however, hay of some sort, with or without corn silage, constitutes this part of the ration. For such, Tables 2 and 3 will solve the problem. From them may be read direct the D.C.P. (Table 2) and T.D.N. (Table 3) contained in any quantity of alfalfa, clover or timothy hay from 8 to 26 lbs. when fed either alone or with corn silage in amounts from 15 to 55 lbs.

Because of the great number of possible combinations involved and the proportionately few cases for which they would be of use, no attempt has as yet been made to prepare tables similar to Nos. 2 and 3, but covering other

TABLE 1.—*Henry and Morrison's Feeding Standards.*

DAIRY COWS

	Pounds of Milk produced per day	PER CENT BUTTER FAT IN MILK 2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
D.C.P. Requirement (milk only)	15	.74	.78	.83	.89	.95	1.00	1.06	1.11	1.18	1.22
	20	.98	1.04	1.10	1.19	1.26	1.33	1.41	1.48	1.57	1.63
	25	1.23	1.30	1.38	1.49	1.58	1.66	1.76	1.85	1.96	2.04
	30	1.47	1.56	1.65	1.79	1.89	2.00	2.12	2.22	2.36	2.45
	35	1.72	1.82	1.93	2.08	2.21	2.33	2.47	2.59	2.75	2.85
	40	1.96	2.08	2.20	2.38	2.52	2.66	2.82	2.96	3.14	3.26
	45	2.21	2.34	2.48	2.68	2.84	2.99	3.17	3.33	3.53	3.67
	50	2.45	2.60	2.75	2.98	3.15	3.33	3.53	3.70	3.93	4.08
	55	2.70	2.86	3.03	3.27	3.47	3.66	3.88	4.07	4.32	4.48
	60	2.94	3.12	3.30	3.57	3.78	3.99	4.23	4.44	4.71	4.89
	65	3.19	3.38	3.58	3.87	4.10	4.32	4.58	4.81	5.10	5.30
	70	3.43	3.64	3.85	4.17	4.41	4.66	4.94	5.18	5.50	5.71
T.D.N. Requirement (milk only)	15	3.65	4.07	4.50	4.93	5.36	5.73	6.09	6.47	6.87	7.19
	20	4.86	5.43	6.00	6.57	7.14	7.64	8.13	8.62	9.16	9.59
	25	6.08	6.79	7.50	8.21	8.93	9.55	10.16	10.78	11.45	11.99
	30	7.29	8.15	9.00	9.86	10.71	11.46	12.19	12.94	13.74	14.39
	35	8.51	9.50	10.50	11.50	12.50	13.37	14.23	15.09	16.03	16.78
	40	9.72	10.86	12.00	13.14	14.28	15.28	16.26	17.25	18.32	19.18
	45	10.94	12.22	13.50	14.78	16.07	17.19	18.29	19.40	20.61	21.58
	50	12.15	13.58	15.00	16.43	17.85	19.10	20.33	21.56	22.90	23.98
	55	13.37	14.93	16.50	18.07	19.64	21.00	22.36	23.72	25.19	26.37
	60	14.58	16.29	18.00	19.71	21.42	22.92	24.39	25.87	27.48	28.77
	65	15.80	17.65	19.50	21.35	23.21	24.83	26.42	28.03	29.77	31.17
	70	17.01	19.01	21.00	23.00	24.99	26.74	28.46	30.18	32.06	33.57

To the above amounts add the following for maintenance.

Wt. of Cow	800	900	1000	1100	1200	1300	1400	1500	1600
Lbs. D.C.P.	.56	.63	.70	.77	.84	.91	.98	1.05	1.12
Lbs. T.D.N.	6.34	7.13	7.93	8.82	9.51	10.30	11.10	11.88	12.68

HORSES

Live	Idle		Light Work		Medium Work		Heavy Work		Nursing Mares	
Weight	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.
900	.81	7.2	.99	9.0	1.22	10.8	1.49	12.6	1.22	9.5
1000	.90	8.0	1.10	10.0	1.35	12.0	1.65	14.0	1.35	10.5
1100	.99	8.8	1.21	11.0	1.49	13.2	1.82	15.4	1.49	11.6
1200	1.08	9.6	1.32	12.0	1.63	14.4	1.99	16.8	1.63	12.7
1300	1.17	10.4	1.43	13.0	1.77	15.6	2.16	18.2	1.77	13.8
1400	1.26	11.2	1.54	14.0	1.91	16.8	2.33	19.6	1.91	14.9
1500	1.35	12.0	1.65	15.0	2.05	18.0	2.50	21.0	2.05	16.0
1600	1.44	12.8	1.76	16.0	2.19	19.2	2.67	22.4	2.19	17.1
1700	1.53	13.6	1.87	17.0	2.33	20.4	2.84	23.8	2.33	18.2
1800	1.62	14.4	1.98	18.0	2.47	21.6	3.01	25.2	2.47	19.3

HOGS and SHEEP, GROWING CATTEE

Live Weight	Hogs		Sheep		Growing Steers		Growing Foals		Growing D. Cattle	
T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.	D.C.P.	T.D.N.
30	.25	1.30								
40	.33	1.73								
60	.35	2.08	.17	1.23						
80	.46	2.78	.21	1.72						
100	.49	3.19	.24	2.10	.32	1.90			.32	1.90
125	.56	3.89	.29	2.38	.37	2.37			.37	2.35
150	.62	4.34	**.41	**2.85	.42	2.83			.42	2.80
175	.65	4.59	**.48	**3.33	.50	3.30			.50	3.28
200	.70	5.16	**.55	**3.80	.58	3.76			.58	3.70
250	.75	5.68	**.69	**4.75	.69	4.52			.69	4.51
300	.78	6.00	**.83	**5.70	.78	5.28	.51	3.60	.78	5.25
400	*1.02	*7.80			.92	6.84	.68	4.80	.92	6.60
500	*1.28	*9.75			1.10	8.35	.85	6.00	1.00	7.90
600	*1.53	*11.70			1.21	9.78	1.02	7.20	1.14	9.00
700					1.40	11.20	1.19	8.40	1.26	9.94
800					1.52	12.48	1.36	9.60	1.35	10.72
900					1.62	13.68	1.53	10.80	1.35	11.34
1000					1.70	14.70	1.70	12.00	1.35	11.35

*Sows with pigs. **Ewes with lambs.

Table 2.—*Pounds of D.C.P. in certain combinations of hay and corn silage.*

Kind of Hay	Lbs.	No Silage	15	20	25	30	35	40	45	50	55
			Lbs. Corn Silage								
Alfalfa Hay	8	.85	1.01	1.07	1.12	1.18	1.23	1.30	1.34	1.40	1.45
	10	1.06	1.23	1.28	1.34	1.39	1.45	1.51	1.56	1.61	1.67
	12	1.27	1.44	1.49	1.55	1.60	1.66	1.72	1.77	1.82	1.88
	14	1.48	1.65	1.70	1.76	1.81	1.87	1.93	1.98	2.03	2.09
	16	1.70	1.86	1.92	1.97	2.03	2.08	2.15	2.19	2.25	2.30
	18	1.91	2.07	2.13	2.18	2.24	2.29	2.36	2.40	2.46	2.51
	20	2.12	2.29	2.34	2.40	2.45	2.51	2.57	2.62	2.67	2.73
	22	2.33	2.50	2.55	2.61	2.66	2.72	2.78	2.83	2.88	2.94
	24	2.54	2.71	2.76	2.82	2.87	2.93	2.99	3.04	3.09	3.15
	26	2.76	2.92	2.98	3.03	3.09	3.14	3.21	3.25	3.31	3.36
Clover Hay	8	.61	.77	.83	.88	.94	.99	1.05	1.10	1.17	1.22
	10	.76	.93	.98	1.04	1.09	1.15	1.20	1.26	1.32	1.38
	12	.91	1.08	1.13	1.19	1.24	1.30	1.35	1.41	1.47	1.53
	14	1.06	1.23	1.28	1.34	1.39	1.45	1.50	1.56	1.62	1.68
	16	1.22	1.38	1.44	1.49	1.55	1.60	1.66	1.71	1.78	1.83
	18	1.37	1.53	1.59	1.64	1.70	1.75	1.81	1.86	1.93	1.98
	20	1.52	1.69	1.74	1.80	1.85	1.91	1.96	2.02	2.08	2.14
	22	1.67	1.84	1.89	1.95	2.00	2.06	2.11	2.17	2.23	2.29
	24	1.82	1.99	2.04	2.10	2.15	2.21	2.26	2.32	2.38	2.44
	26	1.98	2.14	2.20	2.25	2.31	2.36	2.42	2.47	2.54	2.59
Timothy Hay	8	.24	.41	.46	.52	.57	.63	.68	.74	.79	.85
	10	.30	.47	.52	.58	.63	.69	.74	.80	.85	.91
	12	.36	.53	.58	.64	.69	.75	.80	.86	.91	.97
	14	.42	.59	.64	.70	.75	.81	.86	.92	.97	1.03
	16	.48	.65	.70	.76	.81	.87	.92	.98	1.03	1.09
	18	.54	.71	.76	.82	.87	.93	.98	1.04	1.09	1.15
	20	.60	.77	.82	.88	.93	.99	1.04	1.10	1.15	1.21
	22	.66	.83	.88	.94	.99	1.05	1.10	1.16	1.21	1.27
	24	.72	.89	.94	1.00	1.05	1.11	1.16	1.22	1.27	1.33
	26	.78	.95	1.00	1.06	1.11	1.17	1.22	1.28	1.33	1.39

Table 3.—*Lbs. total digestible nutrients in certain hay and corn silage combinations.*

Kind of Hay	Lbs. Hay	No Silage	15	20	25	30	35	40	45	50	55
			Lbs. Corn Silage								
Alfalfa Hay	8	4.13	6.795	7.67	8.56	9.44	10.33	11.21	12.10	12.98	13.87
	10	5.16	7.815	8.70	9.59	10.47	11.36	12.24	13.13	14.01	14.90
	12	6.19	8.845	9.73	10.62	11.50	12.39	13.27	14.16	15.04	15.93
	14	7.22	9.875	10.76	11.65	12.53	13.42	14.30	15.19	16.07	16.96
	16	8.26	10.915	11.80	12.69	13.57	14.46	15.34	16.23	17.11	18.00
	18	9.29	11.945	12.83	13.72	14.60	15.49	16.37	17.26	18.14	19.03
	20	10.32	12.975	13.86	14.75	15.63	16.52	17.40	18.29	19.17	20.06
	22	11.35	14.005	14.89	15.78	16.66	17.55	18.43	19.32	20.20	21.09
	24	12.38	15.035	15.92	16.81	17.69	18.58	19.46	20.35	21.23	22.12
	26	13.42	16.075	16.96	17.85	18.73	19.62	20.50	21.39	22.27	23.16
Clover Hay	8	4.07	6.725	7.61	8.50	9.38	10.27	11.15	12.04	12.92	13.81
	10	5.09	7.745	8.63	9.52	10.40	11.29	12.17	13.06	13.94	14.83
	12	6.11	8.765	9.65	10.54	11.42	12.31	13.19	14.08	14.96	15.85
	14	7.13	9.885	10.77	11.66	12.54	13.43	14.31	15.20	16.08	16.97
	16	8.14	10.795	11.86	12.75	13.63	14.52	15.40	16.29	17.17	18.06
	18	9.16	11.815	12.70	13.59	14.47	15.36	16.24	17.13	18.01	18.90
	20	10.18	12.835	13.72	14.61	15.49	16.38	17.26	18.15	19.03	19.92
	22	11.20	13.855	14.74	15.63	16.51	17.40	18.28	19.17	20.05	20.94
	24	12.22	14.875	15.76	16.65	17.53	18.42	19.30	20.19	21.07	21.96
	26	13.23	15.885	16.78	17.67	18.55	19.44	20.32	21.21	22.09	22.98
Timothy Hay	8	3.88	6.535	7.42	8.31	9.19	10.08	10.96	11.85	12.73	13.62
	10	4.85	7.505	8.39	9.28	10.16	11.05	11.93	12.82	13.70	14.59
	12	5.82	8.475	9.36	10.25	11.13	12.02	12.90	13.79	14.67	15.56
	14	6.79	9.445	10.33	11.22	12.10	12.99	13.87	14.76	15.64	16.53
	16	7.76	10.415	11.30	12.19	13.07	13.96	14.84	15.73	16.61	17.50
	18	8.73	11.385	12.27	13.16	14.04	14.93	15.81	16.70	17.58	18.47
	20	9.70	12.355	13.24	14.13	15.01	15.90	16.78	17.67	18.55	19.44
	22	10.67	13.325	14.21	15.10	15.98	16.87	17.75	18.64	19.52	20.41
	24	11.64	14.295	15.18	16.07	16.95	17.84	18.72	19.61	20.49	21.38
	26	12.61	15.265	16.15	17.04	17.92	18.81	19.69	20.58	21.46	22.35

feedstuffs. Therefore where other feeds are used in conjunction with or in place of hay or hay and silage, calculation must be resorted to. For example, if 10 lbs. of clover hay, 30 lbs. corn silage, and 2 lbs. of dried beet pulp are fed, it becomes necessary to calculate the D.C.P. and T.D.N. in the beet pulp and to add it to that supplied in the hay-silage combination.

Our third step is simple subtraction. The nutrition in the roughage subtracted from the total daily requirement of the animal leaves the amount which must be supplied in the meal allowance. Once this is found we are ready to proceed to the meal mixture, and to make the procedure clearer we may make use of an example.

Let us assume a cow weighing 1000 lbs. and producing 35 lbs. of 4.5% milk. For feed other than meal she is receiving 8 lbs. of clover hay and 40 lbs. of corn silage. The amount of D.C.P. and T.D.N. needed in the meal allowance are found by use of the tables already mentioned. Summarized the data are:

	D.C.P.	T.D.N.
Total Daily Requirements (Table 1)		
Maintenance 1000 lb. cow	.7 lbs.	7.93 lbs.
30 lbs. of 4.5% milk	1.89 "	10.71 "
Total	2.59 "	18.64 "
Nutrition supplied in 8 lbs. clover hay and 40 lbs. of corn silage (Tables 2 and 3)	1.05 "	11.15 "
Amounts of D.C.P. and T.D.N. which must be supplied in meal mixture	1.54 "	7.49 "

Specifications of the Meal Mixture and Amounts of it to Feed.

With the amounts of D.C.P. and T.D.N. which must be supplied in the meal allowance known, it is a simple matter to determine specifications of a mixture which will meet the case.

From our T.D.N. figure (T.D.N. which must be supplied in meal allowance), we first find how many pounds of meal will be needed per cow per day. This amount is dependent upon the proportion of T.D.N. in the mixture, which for ideal dairy cattle feeding should be close to 75%. To get our answer we must solve the problem, 'If 100 lbs. of meal carry 75 lbs. of Total Digestible Nutrients, how many pounds will supply 7.49 lbs. of T.D.N.?'

Here again tables of already calculated values may be made use of, and with Table 4 we can get the answer to the above question at once. In the column headed 75 per cent and opposite 7.5 lbs. T.D.N. to be supplied in meal we find 10. This is the number of pounds of meal which must be fed to meet the T.D.N. requirement provided our meal mixture analyses 75 per cent T.D.N. For mixtures carrying less than this proportion of digestible nutrients other columns in this table are used as is readily understood by inspection of the table.

TABLE 4.—*Pounds of meal needed per day.*

$$\frac{\text{*T.D.N. (1)} - \text{T.D.N. (2)}}{\text{\% T.D.N. (3)}} \text{ equals Lbs. Meal Required per Day.}$$

Lbs. T.D.N. to be supplied in Meal	Per cent TDN in Meal Mixture 75%	70%	65%	60%
	lbs.	lbs.	lbs.	lbs.
1.0	1.3	1.4	1.5	1.7
1.5	2.0	2.1	2.3	2.5
2.0	2.7	2.9	3.1	3.3
2.5	3.3	3.6	3.8	4.2
3.0	4.0	4.3	4.6	5.0
3.5	4.7	5.0	5.4	5.8
4.0	5.3	5.7	6.2	6.7
4.5	6.0	6.4	7.0	7.5
5.0	6.7	7.1	7.7	8.3
5.5	7.3	7.9	8.5	9.2
6.0	8.0	8.6	9.2	10.0
6.5	8.7	9.2	10.0	10.8
7.0	9.3	10.0	10.8	11.7
7.5	10.0	10.7	11.5	12.5
8.0	10.7	11.4	12.3	13.3
8.5	11.3	12.1	13.1	14.2
9.0	12.0	12.9	13.8	15.0
9.5	12.7	13.6	14.6	15.8
10.0	13.3	14.3	15.4	16.7
10.5	14.0	15.0	16.2	17.5
11.0	14.7	15.7	16.9	18.3
11.5	15.3	16.4	17.7	19.2
12.0	16.0	17.1	18.5	20.0
12.5	16.7	17.8	19.2	20.8
13.0	17.3	18.6	20.0	21.7
13.5	18.0	19.3	20.8	22.5
14.0	18.7	20.0	21.5	23.3
14.5	19.3	20.7	22.3	24.2
15.0	20.0	21.4	23.1	25.0

* T.D.N.(1) = T.D.N. required daily by animal.
T.D.N.(2) = T.D.N. supplied in feed other than meal.
%T.D.N.(3) = %T.D.N. in meal mixture.

Before going further it may be well to explain why 75 per cent is taken as the ideal proportion of Total Digestible Nutrients for a dairy cow meal mixture. This figure is one arrived at after analysis of a large number of dairy cattle mixtures which, in addition to their proven worth from the standpoint of general nutrition, meet the requirements of satisfactory meal rations in respect to variety, fibre and bulk. One pound per quart was taken as ideal for bulk and 10 per cent as an upper limit for fibre. Mixtures containing reasonable variety of feeds and meeting the above specifications for fibre and bulk, were found to analyse very close to 75 per cent of Total Digestible Nutrients. Mixtures higher than 10 per cent in fibre were also usually bulkier than the above standard and found lower in their Total Digestible Nutrient content. This does not presuppose that meal combinations lower than 75% in the T.D.N. content are necessarily unsatisfactory, excepting as the amounts of such mixtures needed to supply a given quantity of nutrition necessarily increases as the proportion of digestible material in them decreases. In this respect they are less efficient than more highly digestible combinations. This factor at once involves cost.

TABLE 5.—*Per cent of D.C.P. needed in meal mixtures.*

$$\frac{{}^{*}\text{D.C.P.(1)} - \text{D.C.P.(2)} \times 100}{\text{Lbs. of meal to be fed}} = \%\ \text{D.C.P. required in the Meal Mixture.}$$

Lbs. D.C.P. to be supplied in Meal	Lbs. of Meal to be fed.									
	2	4	6	8	10	12	14	16	18	20
	%	%	%	%	%	%	%	%	%	%
.2	10.0	5.0	3.3	2.5	2.0	1.7	1.4	1.3	1.1	1.0
.4	20.0	10.0	6.7	5.0	4.0	3.3	2.9	2.5	2.2	2.0
.6	30.0	15.0	10.0	7.5	6.0	5.0	4.3	3.8	3.3	3.0
.8	40.0	20.0	13.3	10.0	8.0	6.7	5.7	5.0	4.4	4.0
1.0	50.0	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0
.2		30.0	20.0	15.0	12.0	10.0	8.6	7.5	6.7	6.0
.4		35.0	23.3	17.5	14.0	11.7	10.0	8.8	7.8	7.0
.6		40.0	26.7	20.0	16.0	13.3	11.4	10.0	8.9	8.0
.8		45.0	30.0	22.5	18.0	15.0	12.9	11.3	10.0	9.0
2.0		50.0	33.3	25.0	20.0	16.7	14.3	12.5	11.1	10.0
.2			36.7	27.5	22.0	18.3	15.7	13.8	12.2	11.0
.4			40.0	30.0	24.0	20.0	17.1	15.0	13.3	12.0
.6			43.3	32.5	26.0	21.7	18.6	16.3	14.4	13.0
.8			46.7	35.0	28.0	23.3	20.0	17.5	15.6	14.0
3.0			50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0
.2				40.0	32.0	26.7	22.9	20.0	17.8	16.0
.4				42.5	34.0	28.3	24.3	21.3	18.9	17.0
.6				45.0	36.0	30.0	25.7	22.5	20.0	18.0
.8				47.5	38.0	31.7	27.1	23.8	21.1	19.0
4.0				50.0	40.0	33.3	28.6	25.0	22.2	20.0
.2					42.0	35.0	30.0	26.3	23.3	21.0
.4					44.0	36.7	31.4	27.5	24.4	22.0
.6					46.0	38.3	32.9	28.8	25.6	23.0
.8					48.0	40.0	34.3	30.0	26.7	24.0
5.0					50.0	41.7	35.7	31.3	27.8	25.0

*D.C.P.(1) = D.C.P. required daily by animal.
D.C.P.(2) = D.C.P. supplied in feed other than meal.

When total bulk is not a vital consideration, as with those classes of stock naturally fed roughage, the percentage of T.D.N., or put the other way, the proportion of non-digestible matter in a meal mixture, is directly related to economy. Obviously, if it takes 11 pounds of mixture A to supply the same amount of T.D.N. as can be supplied with 10 pounds of mixture B, due to higher percentage of non-digestible matter in the former, then the A mixture must be bought for less money per ton if we are to get our feed as economically in one case as in the other.

With hog feeding, on the other hand, bulky feeds are decidedly unsatisfactory because of the type of digestive system found in this class of stock. Therefore, quite aside from the question of efficiency, feeds high in non-digestible matter are unsatisfactory to the hog feeder. Hence, feed combinations intended for hogs should not carry less than 75 per cent T.D.N. In fact, other things being satisfactory, a still higher proportion may often be desirable for finishing purposes, though but relatively few combinations which are satisfactory otherwise can be made which carry much more than 75 per cent of T.D.N.

To return now to the main problem, we have found from Table 4 that 10 lbs. of a meal mixture carrying 75 per cent T.D.N. are necessary to supply the seven and one-half pounds of T.D.N. required from the meal

mixture. We must now find out what proportion of Digestible Protein such a meal must carry to meet our requirements in this respect.

Our arithmetic is as follows:

If 10 lbs. of meal are to supply 1.54 lbs. of D.C.P., how many pounds of protein must 100 lbs. of the mixture carry?

The solution of this problem is found in Table 5. In the column headed 10 lbs. of meal and opposite 1.6 in the left hand column of "lbs. D.C.P. to be supplied in meal" we find the figure 16. That is, our meal mixture must carry 16 per cent of D.C.P.

Summarized we find we need 10 lbs. of a meal mixture carrying 75 per cent T.D.N. and 16 per cent D.C.P., to be fed in conjunction with our 8 lbs. of clover hay and 40 lbs. of corn silage.

Compounding the Meal Mixture

Building the meal mixture to these specifications is a simple matter with the use of the Formulae Chart printed on insert page 242A.

The use of this chart is very simple. To make up our mixture carrying 16 per cent Digestible Protein, as required in our example, we find according to the Chart that any one of mixtures Nos. 16, 17 or 18 may be used. In mixture 17, for instance, we use 2 parts of a 7 per cent Protein Feed, 2 of a 9 per cent and 6 of a 21 per cent material. In any group where there are several feeds, we have the possibility of using any combination of such feeds, so long as the total quantity is in conformity with our formulae. Thus we might choose for our 6 parts of 21 per cent feeds, 2 of gluten, 2 of Distillers' grains and 2 of Buckwheat Middlings. Thus there is a wide range of possibilities presented which should make possible advantageous buying.

It will be noted that the extreme left hand column gives the average *Total Protein* analysis corresponding to the respective digestible protein figures of the classes of feeds indicated. This makes it possible to use feeds in the mixtures on which no *digestible* protein analysis is at hand. Thus the average total protein corresponding to the 21 per cent digestible class is 27 per cent. If we have a commercial feed or feed mixture on which there is stated a guarantee of its protein content, it will be the total and not the digestible figure, and by using this first column it is possible to put the feed into its proper class and include it in a mixture so as to make the best use possible of it.

Dept. of Animal Husbandry,
Macdonald College, P.Q.

MEAL MIXING FORMULAE

Parts by weight of feeds which may be combined to give mixtures carrying percentage Digestible Protein as indicated.
(Last two mixtures of each group are hog mixtures).

Av. % Total Protein in Class	Av. % Dig. Protein in Class	Feedstuffs Typical of Protein Classes Indicated	24% Protein					20% Protein					18% Protein					16% Protein					14% Protein					12% Protein					10% Protein				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
10%	7%	Corn, Hominy		1		3		1	2						2			2	2	3	3		3	2	2		2	2	3	1	9		4	4	3		5
12%	9%	Screenings, Barley, Oats, Wheat, Rye, Buckwheat		1	1	2		2	1	3	4	8	2	3	1	3	4	2	2	2	3	4	3	3	3	5	2	4	3	3		5	3	4	5	5	4
18%	13%	Oat Middlings, Wheat Bran, Shorts, Feed Flour	1		1	2	6		1	1	3		1	1	1	5	4	1			2	4	1		2	3	3	2	1	1		4	1	1	2	5	
28%	22%	Gluten, Brewers' Grains, Distillers' Grains, Peas, Buckwheat Midds, Malt Sprouts	5	4	4			4	3	3	1		6	4	4			4	6	4				5	2	1	2	1	3	1		1	2				
34%	30%	Linseed Oilmeal	3	2	3		2	2	2	3			1	2	2	1	1	1		1	1		3		1	1		1		1				1			
45%	38%	Cottonseed Meal (choice), Tankage (low grade), Fish Meal	1	2	1			1	1													2					1										1
60%	56%	Tankage (high grade)				3	2				2	2				1	1				1										1						

DAIRY COW RATIONS

In general use meal mixtures with Digestible Protein contents as follows, according to kind of hay fed:

Alfalfa Hay	10%—12%	Protein
Clover "	12%—16%	"
Mixed "	16%—20%	"
Timothy "	18%—24%	"

Within these limits, the larger the allowance of meal per pound of milk produced, the LOWER the percentage of protein needed in the meal. One pound of meal to three of milk is about average.

HOG RATIONS

Use meal mixtures carrying protein as follows for pigs:

Newly weaned pigs	20%—21%	Protein
Pigs weighing 50 to 125 lbs.	14%—18%	"
Pigs weighing over 125 lbs.	12%—14%	"
Mature breeding stock	10%	"
Nursing Sows	16%	"

Use the higher protein mixtures for the smaller pigs.
Nine pounds of Skim or Butter Milk are equivalent to 1 pound Oilmeal; or 15 lbs. to 1 pound high grade Tankage, and substitutions may be made on this basis without changing the % protein in the mixture.

THE AGRICULTURAL VALUE OF HARD SEEDS OF ALFALFA AND SWEET CLOVER UNDER ALBERTA CONDITIONS.*†

C. W. Leggatt

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In making germination tests on seeds of alfalfa and clovers, a definite number of the seeds is generally placed between moist blotters in a germinator and the germinated seeds counted and removed at intervals. The test is usually considered complete at the end of five days, at which time, however, there are nearly always some seeds which have not absorbed moisture but have remained to all appearances unchanged. These are known as "hard" or impermeable seeds. They are known to be viable, for if scratched slightly and returned to the germinator they will promptly germinate. The question has arisen as to whether they will germinate in the field since they will not do so in the more or less favourable conditions in the germinator.

Harrington (*1*) in an extensive investigation on impermeable seed, covering a large number of crop plants over a considerable period of time, found that conditions of storage affected the degree to which impermeable seeds became permeable; also that the maturity of the seed itself was a factor influencing this. Very few impermeable seeds of clovers, except crimson clover, produced seedlings in the soil even in three months; the case was different, however, with crimson clover, alfalfa, and some others, such seed of alfalfa, selected by the blotter method showing a high percentage of germination. Alternating temperature following a period of low temperature was favourable to the germination of hard seeds of red, alsike, white and sweet clover. Such a condition is found in spring, the natural time for germination, but not typically at any other season of the year. Of seeds wintering on or under the parent plant, only the impermeable seeds of alfalfa survived, and of these only 3% had become permeable when tested in spring. Frost resulted in rendering only a very small percentage (4%) of hard alfalfa seeds permeable, whereas 1% of the hard seeds of sweet clover became permeable under the same conditions. In the field 74% of impermeable alfalfa seeds became permeable in one growing season while only 66% germinated in the germinator in 12½ months. In each series of tests, many impermeable alfalfa seeds produced seedlings in the soil, practically all appearing within the first two months. As the result of his experiments he recommended considering two-thirds of the impermeable seeds of alfalfa as of agricultural value, and varying percentages for other hard seeded crop plants.

Miss Hopkins (*2*) concluded that hard seeds were of doubtful value. Whitcomb (*4*) separated the hard seeds by the blotter method. His results would seem to indicate that the hard seeds in alfalfa were of practically the

*Contribution from the Laboratory Division, Seed Branch, Department of Agriculture, Ottawa, Ont.

†This paper has been divided into four sections. The first three of these deal with the data during the summers of 1925, 1926 and 1927, respectively. The fourth section discusses the work of 1925 in the light of a mathematical method which was not devised till the programme for the 1927 work was drawn up. Had this method been thought of earlier, it would have modified to a great extent, the plans for the two earlier years. Hence it has been necessary for the continuity of the paper to arrange the sections in the order mentioned.

same field value as permeable. He showed (5) that hard seeds of alfalfa germinated better in the field than in the laboratory; the contrary however, was the case with sweet clover. Most of the germination occurred within the first few weeks of the test. Miss Lute, (*3*) obtaining her hard seeds by the blotter method, concluded that some of the impermeable alfalfa seeds get into the stand provided they come up within the first two months.

There appears to be some difference of opinion, as the result of these investigations, in regard to the field value of the hard seeds, chiefly of alfalfa. The general opinion however seems to be that the hard seeds of this species have considerable value, but the majority of the workers quoted have used hard seeds separated by the blotter method. The objection to this is discussed in section II of this paper where experiments are reported in which this method was used before the objection was realized, but it is sufficient to make conclusions based on the method unreliable.

Under the Canadian system of grading the seeds of alfalfa and clovers, the "hard" seeds are added to the germinated seeds in computing the percentage of pure living seed on which the grades are based. In view of the fact that there has been considerable questioning as to the legitimacy of the implied assumption that "hard" seeds are capable of producing plants of agricultural value, it was decided to carry on this investigation, first of all in Alberta, where the rather scanty rainfall might be considered as unfavourable to the germination of "hard" seed, and with alfalfa, which is the principal crop of the type in that province. While considerable work has already been done in this connection, it is believed that this is the first time that the work has been carried on under strictly field conditions on the plan to be outlined later.

The work was started in 1925 and was continued in 1926 with alfalfa, and in 1927 with sweet clover.

Section I.

In the work of 1925, eight samples were chosen having varying percentages of "hard" seeds as shown at the left, Table 1.

Four plots, representing different environmental conditions, were planted, 3,200 seeds being planted in each, or 400 seeds from each sample in each plot. The rows being 1 rod long admitted the planting of 50 seeds in each, spaced 4 inches apart; thus there were 8 rows of each sample. Rows were 3 feet apart, a 6-foot space being left between the 8 rows of one sample and those of its neighbour. Each row was marked by a permanent 2″ x 2″ stake, which bore a nail to serve as an anchor to a surveyor's tape and from which the position of each seed was measured off. Each seed could then be known by a number given by the test number of the seed, the number of the row and the distance in inches from the nail, this arrangement admitting of an individual history for each seed. The test was to be carried over into the following year, in order that the hardiness of the early germinating seed as well as of the late (which were presumably the "hard" seeds) might be determined. In order to avoid differences which might be due to the different quality of the samples, each was cleaned up until nothing but the plump seeds

Table 1.—*Field results and meteorological data, 1925*

LETHBRIDGE

Test No.	Laboratory Check Pre.	Fin.	H.S.	DRY June 3 I	June 23 II	July 23 III	Aug. 25 IV	Sept. 24 V	IRRIGATED June 4 I	June 24 II	July 24 III	Aug. 25 IV	Sept. 24 V	Mean monthly temperatures
205	40	44	54	6	11	13	13	13	19	31	31	34	34	
206	38	43	55	2	7	10	11	11	10	19	21	23	23	May 52.6
908	25	28	70	4	10	17	18	18	27	38	39	41	41	June 59.8
1648	58	68	30	4	7	8	8	9	34	38	40	43	43	July 64.7
4562	49	55	39	2	4	11	11	11	21	29	32	33	34	Aug. 61.5
4740	58	67	32	2	7	10	10	10	36	43	44	44	44	(Data
4957	90	94	3	2	2	3	3	3	28	39	39	40	40	from Dom.
5339	53	56	41	2	2	7	8	9	24	32	40	42	43	Exp. Sta. Leth.)
Total rainfall in inches from date of seeding				0.87	3.70	4.39	6.35	9.40	0.87	3.70	4.39	6.35	9.40	

BROOKS

Test No.	Laboratory Check Pre.	Fin.	H.S.	DOM. IRRIG. EXP. STA. June 16 I	July 8 II	Aug. 4 III	Sept. 8 IV	Oct. 13 V	C. P. R. June 17 I	July 10 II	Aug. 4 III	Sept. 9 IV	Oct. 13 V	Mean monthly temperatures
205	40	44	54	25	33	36	36	37	32	35	37	38	38	May 54.3
206	38	43	55	26	29	33	33	33	32	34	39	39	39	June 60.8
908	25	28	70	29	36	39	40	40	45	47	49	49	49	July 66.1
1648	58	68	30	55	59	59	60	60	53	54	55	55	55	Aug. 63.7
4562	49	55	39	35	43	45	46	46	49	50	52	52	53	Sept. 53.0
4740	58	67	32	43	47	50	51	51	44	46	49	49	49	(Data
4957	90	94	3	30	30	33*	33	33	19	46	48	48	48	from Dom.
5339	53	56	41	32	38	44†	45	45	30	39	43	44	44	Exp. Sta. Brooks.)
Total rainfall in inches from date of seeding				1.33	2.32	4.17	5.19	8.85	1.33	2.32	4.17	5.19	8.85	

* This sample suffered a loss of 6% on account of cutworm, hence this figure should read 27% for plants surviving.

† This sample suffered a loss of 4% on account of cutworm, hence this figure should read 40% for plants surviving.

remained. A chart was prepared corresponding to each row, on squared paper, one square corresponding to each seed, on which was marked the date the seedling was first observed.

The plots were all cut in the fall to a height of about 4 inches in order to prevent shedding of seed and thus disturbing the following year's work on these plots.

Two of the plots were situated at Brooks, and two at Lethbridge, both irrigated areas. One plot at the latter point was given no irrigation, the other one 4″ irrigation, while both plots at Brooks received two 4″ irrigations. The plots at Lethbridge were sown about May 8, and at Brooks about May 26. A count was made three weeks after sowing, again in three weeks and monthly thereafter. Table 1 shows the results obtained together with details as to rainfall, temperatures, etc.

In examining these results, there is evident a general correlation between the amount of germination obtained and the amount of water supplied. On the dry plot at Lethbridge germination throughout is very low; this point will be taken up later. In the other plots, however, the average germinations of all samples are 38% for Lethbridge, 43% for D.I.E.S.* plot, Brooks, and 47% for C. P. R. plot, Brooks. The rainfall and irrigation received by both

*Dominion Irrigation Experiment Station.

plots at Brooks were the same. There must have been present some other undetermined factor which favourably influenced germination in the C. P. R. Brooks' plot. It was observed, however, that the soil at the D. I. E. S. plot was much more porous than the C. P. R. plot, which appeared the more suited to retain moisture.

In these three plots possibly the most striking feature is the poor showing of sample No. 4957, which had only 3% hard seeds in the laboratory "check" test.

In sample No. 908 it will be observed that in all the irrigated plots the germination obtained was considerably higher than that in the laboratory. In this connection it might be remarked that in tests to ascertain the relative value of laboratory tests as a criterion of the field value of the seed in question, there has been shown to be a difference of from 10 to 20 per cent in favour of the more or less ideal conditions of the laboratory. Hence, in considering these results and making allowances on this basis it will be seen that in many cases there is shown to be a field germination of some of those seeds which the laboratory tests show as hard.

It will be noticed that in the irrigated plots there was but little germination after the second count, and that there is less difference between first and second counts at Brooks than on the irrigated plot at Lethbridge. It seems reasonable to conclude from this, having regard to the dates, that most of the germination was concluded in the field by the end of June.

In analyzing the figures giving the final counts for each plot by finding the mean for each plot and the departure from that mean for each sample, and then averaging for the three plots to neutralize irregularities in conditions which might have affected adversely or otherwise the germination of any sample in any one plot, the figures shown in Table 2 are obtained:—

TABLE 2.—*Average departure from mean germination compared with the percentage of hard seeds.*

Sample No.	Hard Seeds %	Average departure from the mean
205	54	— 6.26
206	55	—10.59
908	70	+ 0.66
1648	30	+10.16
4562	39	+ 1.82
4740	32	+ 5.32
4957	3	— 2.34
5339	41	+ 1.26

From this it will be seen that there is no apparent correlation between their departure from the mean and their percentage of hard seeds, and that therefore between extremes of 20% these samples have the same value in the field, this variation depending probably on such considerations as vigour of seedlings, etc.

At the time the field results were secured it was a matter of considerable surprise that sample No. 4957 with only 3% of hard seeds should have made such a poor showing. This, however, is quite in accordance with results reported later in this paper.

SECTION II.

While the results of the 1925 work were rather inconclusive, they seemed to indicate many points on which improvement might be made in another year's work.

These points which were taken into consideration in the programme of 1926 were the following:—

(1) Choice of Samples. It was found that where the full history of the sample was not known, and where many varying degrees of "hard" seed content were employed, interpretation of results became extremely unsatisfactory. For this reason, two samples, A and B were chosen, which were divided into the (ideal) separations indicated in Table 3.

TABLE 3.—*Details of samples used in 1926 investigation (alfalfa).*

No.	Bulk Sample	History	Germ. in Lab. Test made at time of first planting. Germ. 5 days	Hard Seeds
1	A	Hand rubbed sample. About 1 oz. germinated between wet blotters and hard seeds removed after 5 days. Representing 100% hard seeds	5	95
2	B	" " " " "	5	95
3	A	Machine threshed sample. About 1 oz. germinated between wet blotters and hard seeds removed after 5 days. Representing 100% hard seeds.	4	96
4	B	" " " " "	4	96
5	A	Untreated sample, machine threshed	66	33
6	A	" " hand rubbed	29	70
7	A	Scarified, representing 100% germination	98	2
8	B	" " " "	98	2

(2) It was felt that more useful results could be obtained with plots situated in a district where irrigation was unnecessary, in addition to a plot in an irrigated district, rather than in the latter only. Accordingly, three plots were planted in the Lacombe district on black loam soil, and one at the D. I. E. S. at Brooks on sandy silt soil.

(3) *Tilth of soil and irrigation.* In the plots used for the 1925 work, the soil is of a "gumbo" nature. This soil cakes badly, particularly where flooded by irrigation water. This condition caused much difficulty, particularly in trying to prepare a fine seed bed for the experiment. The irrigated plot at Brooks for the 1926 work was in a very good state of tilth, and great care was taken to subirrigate so that the soil should not cake in the rows. Further, in preparing the rows in all plots, all lumps were carefully raked off. This was not considered unfair, since at the rate of seeding usually employed a very considerable proportion of the seed must find conditions as ideal as those provided here. The seeds were planted ¾ to 1″ deep.

(4) *Date of planting.* It was considered desirable to obtain data as to the behaviour of hard seeds when planted at different dates. Accordingly, one plot at Lacombe was sown on April 28, one three weeks later on May 11 and one three weeks later on June 2. The Brooks plot was sown on May 18. The two latter dates are normal for the two districts respectively.

(5) *Spacing of seeds and rows.* It was found that wider spacing than that employed in 1925 was preferable, so in the 1926 work each seed was planted 6 inches from the next, and the rows were 4 feet apart.

The first count was made after four weeks, the second three weeks later, and counts thereafter at intervals of four weeks. As before, seedlings were left in, as it was intended to carry on the work on these plots into the following year.

The results obtained are shown in Table 4.

At Brooks, very complete soil moisture determinations were obtained at the time of seeding. At the time of the first count, the accompanying graph (Fig. 1) was prepared which shows the relation between the percentage

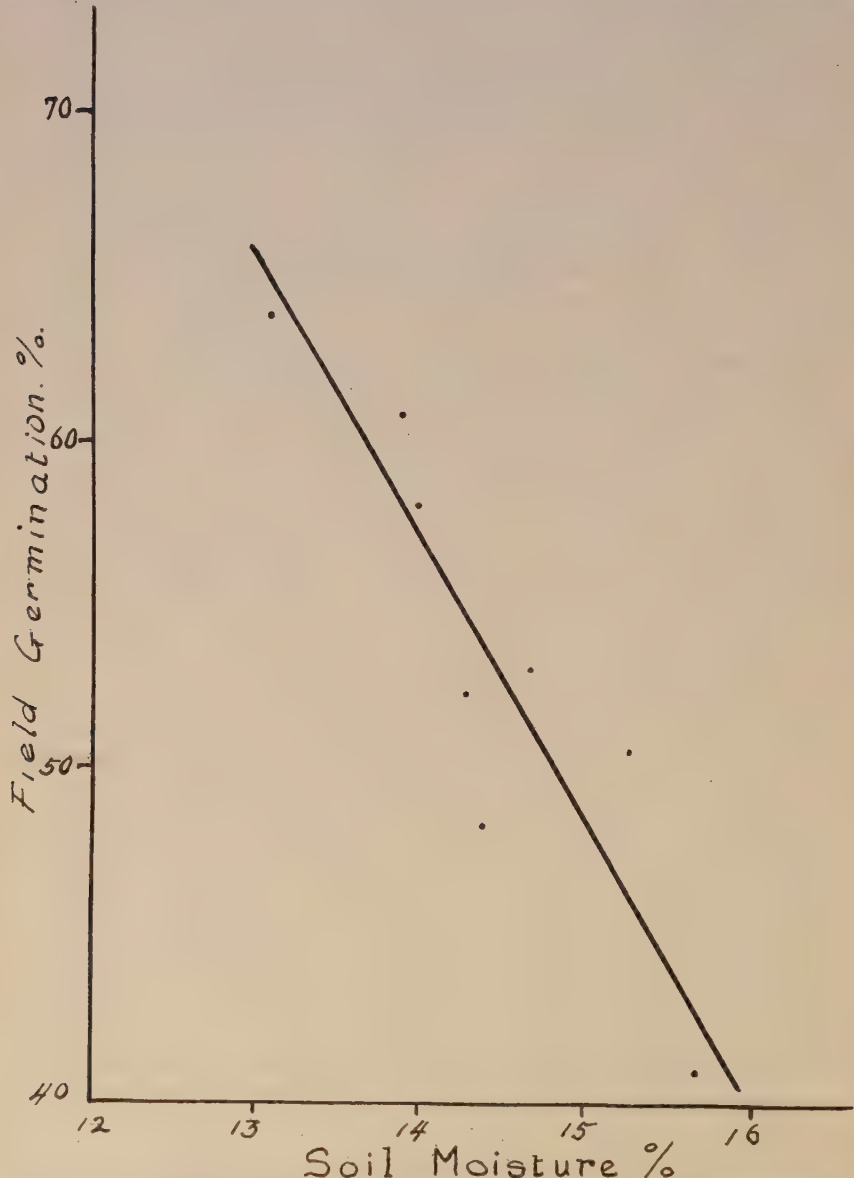

FIGURE 1.—Graph showing relation between soil moisture at date of seeding and per cent germination at first count. (Brooks Plot.)

Table 4.—*Field results and meteorological data, 1926*

LACOMBE PLOTS

Inv.	Bulk	Lab. Test after 5 days		No. 1 (Seeded April 28, 1926) Dates of counts					No. 2 (Seeded May 11, 1926) Dates of counts					No. 3 (Seeded June 2, 1926) Dates of counts				
No.	sample	Germ.	H.S.	May 26	June 15	July 13	Aug. 10	Sept. 7	June 8	June 29	July 28	Aug. 23	Sept. 29	June 30	July 20	Aug. 16	Sept. 13	Oct. 11
1	A	5	95	9	29	36	55	56	24	34	54	57	57	38	63	80	82	82
2	B	5	95	22	34	47	65	67	26	35	49	52	54	52	72	85	88	88
3	A	4	96	16	40	59	73	75	28	41	67	70	70	43	83	92	95	95*
4	B	4	96	15	33	43	53	55	25	37	50	54	54	41	75	88	90	90
5	A	66	33	33	46	52	57	58	39	44	59	62	63	66	79	87	87	87
6	A	29	70	39	47	53	59	61	35	42	61	63	63	48	61	77	78	78
7	A	98	2	47	51	53	53	53	44	47	47	49	49	67	68	69	71	71
8	B	98	2	42	48	49	50	50	62	64	65	66	66	68	69	70	70	70
Rainfall in inches from date of seeding				1.01	4.57	5.77	9.11	15.49	4.05	5.17	7.70	10.96	16.07	1.95	4.14	5.95	12.02	13.49

* Average 7 rows, barley adjacent to plot seeded too close.

Mean Weekly Temperatures from date of seeding first plot. (Lacombe District.)

Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.
May 4	54.2	69.9	38.6	June 15	48.9	59.9	37.9	July 27	63.0	73.1	47.4	Sept. 7	53.1	60.6	45.6
" 11	47.4	60.7	34.0	" 22	53.2	66.4	40.0	Aug. 3	57.7	72.8	42.6	" 14	46.8	60.6	32.9
" 18	52.5	67.8	37.3	" 29	62.4	78.0	47.0	" 10	52.9	64.9	40.8	" 21	35.3	45.4	25.2
" 25	51.2	65.7	36.7	July 6	64.5	80.0	48.3	" 17	52.0	63.3	40.7	" 28	33.2	46.9	19.4
June 11	52.4	66.3	38.7	" 13	65.9	83.1	48.6	" 24	57.1	72.1	42.1	Oct. 5	48.5	61.9	35.0
" 18	53.9	67.0	41.0	" 20	56.1	68.3	43.8	" 31	57.7	69.3	46.1				

BROOKS PLOT (Seeded May 18, 1926)

Sample	Lab. Test after 5 days		Dates of counts					Mean Weekly Temperatures from date of seeding.							
No.	Germ.	H.S.	June 10	July 5	Aug. 2	Aug. 30	Sept. 27	Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.
1	5	95	41	57	68	69	69	May 24	56.6	70.5	42.7	Aug. 2	65.7	82.3	49.2
2	5	95	53	66	71	73	73	" 31	57.2	72.9	41.5	" 9	62.4	76.2	48.6
3	4	96	64	75	77	77	77	June 7	60.3	75.9	44.7	" 16	56.9	67.9	45.8
4	4	96	61	77	79	80	80	" 14	54.3	71.1	38.9	" 23	59.9	73.7	49.6
5	66	33	53	62	63	63	63	" 21	56.4	68.9	44.0	" 30	64.4	81.2	47.6
6	29	70	58	67	71	71	72	" 28	67.2	83.6	53.9	Sept. 6	56.2	65.4	46.9
7	98	2	51	54	56	56	56	July 5	68.0	82.0	53.9	" 13	52.0	64.8	39.2
8	98	2	49	50	51	51	51	" 12	73.5	90.6	56.4	" 20	42.4	53.2	31.6
								" 19	66.8	82.4	51.1	" 27	34.8	46.0	23.6
Rainfall in inches from date of seeding			0.55	2.20	2.60	4.42	6.18	" 26	66.4	83.5	49.2				
Moisture in inches including irrigation (from date of seeding)			4.55	6.20	10.60	12.42	14.18								

germination obtained at the 4-week count at Brooks and the soil moisture to a depth of 3 inches in each sample plot. While it is doubtful whether too much should be read out of this with the data to hand, it seems indicated that the optimum soil moisture percentage is somewhat lower than actually obtained then, while it is not unreasonable to suggest that the variations in germination that have been obtained may be due rather to the soil conditions than to the percentage of hard seeds.

In examining the figures given in Table 4, the following points will be noticed.

Plot 3 at Lacombe and the Brooks plot have in all samples given the highest results. These plots were seeded at the date which is normal for these districts, the dates at which plots Nos. 1 and 2 were sown being considered early for that locality.

Plot No. 3 (Lacombe) shows much more complete germination than the Brooks plot, with which it compared fairly closely at the second count, even though at that time it was yet a little higher. In view of the graph showing the possible correlation between the percentage of soil moisture and germination, it seems as if this factor may have a bearing on the results. The No. 3 plot also shows less moisture on the whole than Nos. 2 and 1, though in the latter the water carried over in the surface soil from the winter probably more than compensated for the slightly less rainfall during the corresponding periods between it and No. 3.

Other factors which might influence the germination are temperature and the nature of the soil. While the Brooks plot was subject to somewhat higher average temperatures, the fact that the soil is rather lighter in colour, while that at Lacombe is very dark, would tend to counterbalance this, since dark soils absorbs more heat than light soil. Moisture, then, seems the deciding factor.

While there is some difference in the actual percentages of germination between the different plots, there is considerable uniformity in the relative. Table 5 shows the averages of the final counts for the two plots which are normal for the date of seeding in the two districts (Lacombe and Brooks), arranged in order of germination.

TABLE 5.—*Average germination Lacombe No. 3 and Brooks.*

Order	Sample No.	Average Germination
1	3	86
2	4	85
3	2	80
4	1	75
5	5	75
6	6	75
7	7	63
8	8	60

The samples are seen to fall fairly naturally into three groups as indicated by the brackets, corresponding to the treatment they have received. The four samples selected for hard seeds show the highest germination, the machine-threshed samples Nos. 3 and 4 averaging the highest of all,

followed very closely by the two samples which were unscarified but machine-threshed and hand-rubbed respectively, while the two scarified samples show the lowest germination. A criticism which has been brought to the author's notice is that samples selected for hard seeds by the blotter method show a marked increase in germination after drying and storing for a while (Schmidt; prior to publication). This would account for the higher germination shown by samples Nos. 1 to 4, but it cannot be applied to samples 5 and 6. These latter have shown very concordant results throughout, and this in spite of their different laboratory performance. While, then, we cannot account the higher germination of Nos. 1 to 4 as significant with respect to their hard-seededness, we can at least class them in a group with 5 and 6, considering the two latter as more or less standard for the bulk samples in question.

Comparing now the scarified samples 7 and 8, we see that they average more than 10% lower in germination, and it appears that scarification in this case has actually produced harmful results. It may be pointed out, however, that on account of the heavy scarification (sufficient to raise the germination to 98% when put through the machine but once) actual injury may have been done to the seeds, though this did not appear in the laboratory test. At that time, however, no attention was being paid to broken and weak sprouts.

Sample No. 6 stands out in that it shows a high percentage of natural hard-seededness, unmodified in any way; yet it shows no less readiness to germinate on this account.

So far we have been discussing final results as they stood at the end of the season. Since germination near the end of the season may be of less value, it is necessary to enquire as to whether the differently treated samples showed any differences in this respect. In this connection, however, it should be borne in mind that in a crop such as alfalfa, where the crop is expected to be on the soil for a period of years, any seeds germinating rather late might be considered as of full value, provided the resultant plants are sufficiently established to survive the winter. This point was determined by observations and further counts the following season and is discussed a little later.

Plot No. 1 Lacombe. This plot, being sown early, had less favourable conditions than subsequent ones. The germination of the scarified samples (7 and 8) was more prompt, increasing but little from the first count to the end of the season. Samples 5 and 6 are intermediate between these and samples 1 to 4 which show very low germination. By the second count, however, (June 15), 5 and 6 have practically caught up to 7 and 8, while by July 13 this is nearly true of the selected samples (except No. 1). By the 10th of August all samples have exceeded, some by a considerable amount, the performance of the scarified.

While the unfavorable date of seeding was less detrimental to the scarified than to the remaining samples, from the point of view of prompt germination, yet the latter probably made up for this setback soon enough to be of practical value.

Plot No. 2 Lacombe. Practically the same remarks would apply to this plot as to No. 1, paying regard to the difference of the dates. In this plot one scarified sample, however, (8), shows very high comparative germination, which is evidenced very early; it is the second highest germinating sample in the plot. There is little increase in any sample after the third count. (cf. Plot No. 1 where there is considerable. It is probable, however, that there is not much increase in germination in either plot after the same date).

Plot No. 3 Lacombe. Here again samples 7 and 8 show more prompt germination, but by the second count, (July 20), most of the samples have more than caught up, and are far ahead in the remaining counts.

This plot shows markedly higher results in all samples than any of the other plots. The soil, moisture and other conditions must have been exceptionally favourable, yet samples 7 and 8 barely exceed 70% germination.

Brooks Plot. In this plot the scarified samples show no advantage in speed of germination over the others; in fact, on the whole, rather the reverse is the case. By the second count (July 5) samples Nos. 1 to 6 have considerably exceeded 7 and 8 in performance.

An interesting point in this plot was that quite a marked difference was observable between the plants from the scarified seeds and those from the selected hard seed samples. The latter were perceptibly more vigorous than the former.

In the early summer of 1927 a check-up was made to determine the number of plants surviving the winter, and to discover if any further germination occurred.

These results are shown in Tables 6 and 7.

TABLE 6.—*Percent plants in evidence Fall 1926 and at 1927 check-up.*

No. Sample	Brooks Plot 1926	Brooks Plot 1927	Lacombe No. 1 1926	Lacombe No. 1 1927	Lacombe No. 2 1926	Lacombe No. 2 1927	Lacombe No. 3 1926	Lacombe No. 3 1927
1	62	58	47	49	44	43	77	77
2	67	60	57	57	46	45	83	80
3	73	66	65	64	62	62	88	85
4	73	68	45	44	46	45	86	85
5	58	52	39	39	54	54	83	82
6	64	53	47	47	54	55	71	73
7	48	44	34	33	42	42	64	63
8	41	36	32	33	53	55	58	57

The Brooks plot shows a considerable loss due to winter killing, while the other plots show either a slight loss for the same reason or a slight increase on account of seeds germinating in the spring of 1927. All plots were cut down to a height of 4 inches to avoid self-seeding, thus robbing them of their natural winter protection. At Lacombe, however, the snowfall is much heavier than at Brooks, and while the plots were not inspected during the winter, it seems probable that this accounts for the difference between the plots in the two localities.

There appear to be no consistent differences shown by any of the samples in winter hardiness; all appear to have been affected about equally.

TABLE 7.—*Additional germination 1927 (%)*

Sample No.	Brooks	Lacombe No. 1	Lacombe No. 2	Lacombe No. 3
1	----	0.50	----	0.25
2	----	---	----	---
3	----	---	0.50	---
4	----	0.25	0.25	---
5	----	---	0.50	---
6	----	---	---	---
7	----	---	---	0.25
8	----	---	---	---

The additional germination shown in Table 7 is quite insignificant. We may conclude that all the germination of practical value in alfalfa is likely to occur during the year of seeding under the conditions prevailing during the season under consideration, when the winter was very severe. Apparent inconsistencies in Tables 6 and 7, e.g. in sample No. 1 Lacombe Plot No. 1 in which an increase of 0.5% germination appears to have produced an increase of 2% in the number of plants, are due to the fact that some plants which, having germinated, had disappeared in the fall but reappeared in the spring.

In order to determine the winter-survival value of plants germinating at different counts, a check was made of those plants of each count which were present in the following spring. These were totalled for all samples, each plot being considered separately. These numbers divided by the corresponding total numbers of plants of any one count present in the fall × 100 give the relative winter-survival values of plants germinated at the count in question. Since, as has just been explained, some plants were not in evidence in the fall check-up, 1926, though previously germinated but were present in the following spring, these must be included in this number. These figures are shown in Table 8.

TABLE 8.—*Winter survival value of plants produced from seeds germinating at different counts.*

Count No.	Plants present in check-up, 1927	Plants present in fall, 1926	Winter Survival value%
Brooks Plot			
1	1385	1555	89.1
2	262	289	90.7
3	82	99	82.8
4	10	10	100.0
5	1	1	100.0
Lacombe No. 1 Plot			
1	604	881	68.6
2	345	416	82.9
3	226	246	91.9
4	266	284	93.7
5	25	25	100.0
Lacombe No. 2 Plot			
1	909	1120	81.2
2	213	238	89.5
3	405	423	95.8
4	64	64	100.0
5	8	8	100.0
Lacombe No. 3 Plot			
1	1571	1676	93.7
2	570	585	97.4
3	268	289	92.7
4	23	24	95.8
5	1	1	100.0

In examining this Table it should, first of all, be borne in mind that in the last two counts of some of the plots, the number of plants present in fall and spring respectively are so low that the percentage figure of winter-survival is not as reliable as might be desired. Nevertheless, there is shown to be a very marked and fairly consistent increase in winter hardiness with lateness of germination. In a mathematical analysis of the 1925 work, reported later in this paper it will be shown that the permeable seeds are inclined to give earlier germination than the hard. In view of this we may conclude that the plants produced by the hard seeds are more winter hardy than the permeable seed plants. This affords an interesting confirmation of the increased relative agricultural value of the hard seeds in the following spring as reported in Section IV. of this paper.

Summing up the observations on the plots seeded in 1926:—

In considering each plot separately it has been observed that the scarified samples, as a rule, though not always, germinate more promptly than the others. This advantage is soon lost, however, and (proportionately) progressively sooner as the date of seeding more nearly approaches the normal for the district.

Laboratory tests on machine threshed seed, which has undoubtedly undergone a certain amount of incidental scarification, show as hard, some seeds which apparently are rather more valuable than either regularly scarified or absolutely unscarified seed. Possibly this may be due to a very slight abrasion of the surface insufficient to procure germination in the laboratory in 5 days, though sufficient to do so in due time in the field, while in scarified seed there may be more or less injury which might not show in the laboratory test.

The scarified samples were shown to germinate more than 10% lower in the field than the unscarified, though the possibility of the samples having received a scarification that was excessive should be borne in mind. This is true, even in comparison with the sample which was hand-rubbed, and that machine threshed, thus offsetting the possible criticism that the method of selecting hard seeds resulted in softening them.

Cold, wet weather appears less favourable to prompt germination of hard seeds than of scarified, which is an important consideration on irrigated land.

Little additional germination was found to have occurred on examination of the plots in the early summer of 1927, but plants produced by hard seeds appeared to be more winter-hardy than those produced by permeable seeds.

We may conclude from the two years' work on alfalfa that the hard seeds have just as much agricultural value as the permeable, at least under Alberta conditions and for the two seasons in question. Additional evidence of their value is provided in section IV of this paper.

Section III.

The material for the hard seed investigation in 1927 has been White Blossom Sweet Clover (*Melilotus alba*). This was chosen since it is of

greater present importance as a crop in Alberta than White, Alsike or Red Clovers, and is believed to afford the opposite extreme to alfalfa with respect to hard-seededness.

Exactly the same technique was followed as with the 1926 work previously described. This year, however, it was necessary to reduce by one quarter, the actual number of seeds planted, viz., 300 instead of 400 seeds of each sample in each plot. This was thought to be insufficient to affect the reliability of the results materially, and was necessary on account of yield trials of scarified and unscarified alfalfa, which were put in this spring to complete the work on alfalfa of 1925 and 1926.

Three plots were again seeded at different dates at Lacombe, this year at the Dominion Experiment Station and one plot was sown at the D. I. E. S. at Brooks. The Brooks plot received one 4″ irrigation, but irrigation is not necessary in the Lacombe district.

In considering the interpretation of results in the work of 1925, it was felt that if samples having 100% hard seeds could be used as test samples, the agricultural value of the hard seeds could thus be obtained direct. This was done by the blotter method in 1926 but it was pointed out that hard seeds thus selected are affected in such a way that they germinate more readily than in their normal condition.

Alternatively it was suggested that samples with 100% permeable seeds might be used as control samples. By deducting the percentage of permeable seeds of the test samples capable of field germination, as indicated by the control, from the total field germination, the remainder would give the germination of the hard seeds. This, however, has the drawback that in obtaining a sample with 100% permeable seeds by scarification, much damage may be done to the seeds and it is doubtful whether their field germination would really represent that of the permeable seeds in an ordinary sample.

In view of these facts it occurred to the author that if a series of samples, such as might be found in the trade, were selected, having varying percentages of hard seeds, and were planted in the field using the same technique, the agricultural value of the hard seeds and the permeable, (thence the relative value of hard seeds in terms of permeable) might be calculated mathematically according to the following method.

Since the object of this investigation is to find a figure which will represent the relative value of the hard and permeable seeds, it must be assumed that in any one species, the agricultural value of the hard seeds will always bear approximately the same relationship to that of the permeable; otherwise it would be necessary to determine the relationship for different varieties, then for different strains, or in the ultimate limit for different samples, and the whole problem would cease to have any practical bearing.

Keeping this in mind then, consider a number of samples of a given species. They have different percentages of permeable and impermeable seeds as shown by the laboratory test, but all have this in common by the hypothesis above, that the agricultural values of their hard and permeable seeds are the same. We have thus for this series of samples two unknowns which we may call x and y, where x is the per cent field germination of the hard seeds, and y is that of the permeable.

Now, considering any one sample, suppose it to have $q\%$ hard seeds as shown by the germination test and $r\%$ of permeable seeds. Then in the field, since $x\%$ of the hard seeds germinate, $\frac{x \times q}{100}$ represents the actual field germination of the hard seeds; similarly $\frac{y \times r}{100}$ represents that of the germinable seeds, and the total field germination, which may be called s will be represented by $\frac{x \times q}{100} + \frac{y \times r}{100}$

Thus we have the general equation:

$$\frac{xq}{100} + \frac{yr}{100} = s \text{ of the form: } \quad ax + by = n$$

This equation is applicable to all samples, since x and y, the unknowns, are common to each.

We have then a series of equations, one representing the experimental results on each sample. If we had only two samples, the equations might be solved as ordinary simultaneous equations. In fact it was originally intended to find separate solutions thus, for x and y, by pairing the equation of one sample with each of the equations of all the others in turn, and averaging the numerous values for x and y thus obtained. For this purpose general formulae were worked out giving the values of the two unknowns in terms of the experimental results observed for any pair of samples.

At this point the author consulted Dr. J. W. Campbell, Professor of Mathematics, University of Alberta, to whom he gratefully acknowledges his indebtedness for suggesting the method of least squares as giving the most probable solution to such a series of equations.

With this equation method it is unnecessary to prepare samples with especially high or low percentages of hard or permeable seeds; samples presenting a moderate variation in these respects being better taken from ordinary trade sources. The results then obtained represent the average performance of the hard and permeable seeds of ordinary samples as found in the trade, and thus have a direct practical bearing.

Table 9 gives details of the samples chosen for the 1927 work.

TABLE 9.—*Details of samples used in 1926 investigation (sweet clover).*

Plot No.	Laboratory test count after 5 days: Germ.	H. S.	Weak	Broken	Details
1	36.75	57.25	5.50	0.50	
2	21.00	77.25	1.50	0.25	
3	58.00	32.25	5.50	---	
4	84.75	6.75	4.75	3.75	
5	66.25	27.50	2.25	1.00	Sample flail threshed: as received.
6	69.50	24.00	2.50	1.50	Same sample cleaned: 15% dockage.
7	86.00	5.00	4.75	2.50	Same sample scarified by hand 50 rubs.
8	80.50	14.75	1.50	1.50	Same sample scarified by hand 20 rubs.

TABLE 10.—*Field results and meteorological data, 1927.*

LACOMBE PLOTS

Inv. No.	Lab. Test after 5 days* P. S.	H. S.	No. 1 (Seeded May 3, 1927) Date of counts: May 31 I	June 20 II	July 13 III	Aug. 18 IV	Sept. 7 Final Check	No. 2 (Seeded May 11, 1927) Date of counts: June 6 I	June 20 II	July 14 III	Aug. 24 IV	Final Check	No. 3 (Seeded June 1, 1927) Date of counts: June 20 I	July 15 II	Aug. 9 III	Sept. 8 IV	Final Check
1	37	57	1	2	6	8	8	18	32	35	37	Fourth count constitutes final check	15	17	19	20	Fourth count constitutes final check
2	21	77	6	9	15	17	18	17	21	25	26		13	18	21	21	
3	58	32	21	21	23	29	29	27	32	32	34		22	27	28	28	
4	84	7	33	34	36	36	37	32	39	42	44		19	21	21	22	
5	66	28	30	32	36	36	36	22	24	25	27		15	19	19	19	
6	70	24	40	44	46	46	46	30	34	35	37		14	19	21	22	
7	86	5	20	21	22	22	23	31	35	39	40		14	17	18	18	
8	80	15	22	25	28	29	29	22	25	27	28		22	32	34	35	
Rainfall in inches from date of seeding			2.03	3.79	7.42	11.52	13.25	1.79	3.31	6.95	11.23		1.76	5.40	8.99	11.22	

Mean Weekly Temperatures from date of seeding first plot (Lacombe District)

Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.
May 10	42.6	51.2	31.2	June 21	58.1	71.7	44.6	Aug. 2	58.1	71.9	44.4	Sept. 13	50.5	62.1	39.0
" 17	49.0	61.6	36.4	" 28	58.1	58.1	46.9	" 9	62.0	77.9	46.1				
" 24	46.8	57.0	35.6	July 5	53.5	61.1	45.9	" 16	59.6	73.3	45.9				
" 31	47.6	58.0	37.3	" 12	59.4	72.7	46.1	" 23	59.6	71.9	47.4				
June 7	55.8	70.0	41.6	" 19	61.2	73.4	49.0	" 30	58.6	72.4	44.9				
" 14	54.8	64.7	44.9	" 26	66.0	80.6	51.4	Sept. 6	54.1	68.6	39.6				

BROOKS PLOT (Seeded June 3, 1927)

Inv. No.	Lab. Test after 5 days* P. S.	H. S.	Dates of counts: June 15 I	July 6 II	Aug. 4 III	Aug. 30 IV	Final Check	Mean Weekly Temperatures from date of seeding. Week end	Mean Temp.	Mean Max.	Mean Min.	Week end	Mean Temp.	Mean Max.	Mean Min.
1	37	57	30	54	55	55	Fourth count constitutes final check	June 10	60.1	72.4	47.8	July 29	67.3	80.8	53.9
2	21	77	11	18	19	21		" 17	59.6	71.5	47.8	Aug. 5	63.3	78.5	48.0
3	58	32	30	61	16	65		" 24	62.7	74.9	50.5	" 12	64.9	80.2	49.6
4	84	7	42	60	61	62		July 1	61.4	75.4	47.4	" 19	62.3	74.2	50.4
5	66	28	42	55	55	57		" 8	62.9	74.6	51.2	" 26	62.3	76.5	48.1
6	70	24	44	61	61	62		" 15	64.1	77.6	50.6	" 31	61.5	76.6	45.5
7	86	5	42	54	55	57		" 22	66.7	78.9	54.6				
8	80	15	45	53	54	55									
Rainfall in inches from date of seeding			2.09	4.46	6.44	7.44									
Moisture in inches including irrigation from date of seeding			2.09	4.46	.644	11.44									

* Broken sprouts not included.

It will be observed that samples 7 and 8 are in some sense artificial, in that they have been scarified by hand. The full implications of the method were not realized at that time, and hence these samples were included. However, the scarification was done with care, and without excessive injury to the seed, as is evident from the fact that there is not an undue proportion of weak and broken sprouts in these samples as compared with some of the others. In any case, such weak and broken sprouts were not included as germinated in computing the results.

Table 10 shows the results obtained in the field together with experimental data as to the precipitation and temperature during the course of the season.

There was unfortunately some loss owing to cutworm in some of the plots. This mainly affected Lacombe plot No. 1. The results obtained do not indicate that seedlings from hard seeds were affected any less than those from permeable. This is discussed more fully further on. But when a sample gives results which appear unaccountably out of line with the general trend in the plot, the weight, or p, credited to that sample in the method of least squares, has been reduced. Thus p for the second sample in the Brooks plot is only ½ as compared with 1 for all the rest, while sample No. 1 in the Lacombe plot No. 1 is given $p = ½$.

Using this method, the field germinations of both the hard and permeable seeds were calculated for each plot and at each count. The results provide an interesting insight into the actual behaviour of the two components as the season progresses.

Table 11 gives the results of these computations for the respective plots.

TABLE 11.—*The field germination of hard and permeable seeds as calculated by using the method of least squares.*

	Count No.	Field Germ. Hard Seeds	Field Germ. Perm. Seeds	Ag. Val. H.S. where P.S.=100
A. Brooks Plot	1	11.3	52.4	21.6
	2	33.5	68.5	48.9
	3	34.3	69.3	49.5
	4	36.0	70.9	50.8
B. Plot No. 1 Lacombe	1	0	36.2	0
	2	2.0	37.9	5.3
	3	9.9	39.1	25.4
	4	12.6	39.7	31.8
	Final Check	13.2	40.1	32.9
C. Plot No. 2 Lacombe	1	12.0	33.8	35.5
	2	20.7	38.0	54.5
	3	23.8	40.1	59.1
	4	25.6	41.8	61.2
D. Plot No. 3 Lacombe	1	13.1	20.3	64.6
	2	17.1	25.6	67.0
	3	20.5	26.1	78.5
	4	20.7	26.7	77.5

In all plots there is seen to be a progressive increase in the field germination of both the hard and permeable seeds. This increase is relatively more marked for the hard seeds. The Brooks plot (Table No. 11 A)

shows a relatively greater increase in this respect for the permeable seeds, between the first and second counts. It is to be noted that in this plot the first count was made only 12 days after sowing, which clearly accounts for this difference.

The greater promptness of germination of the permeable seeds is very marked in Plot No. 1 Lacombe (Table 11B). The hard seeds show no field germination at the first count and only 2% at the second, while the permeable seed has germinated within about 4% of its ultimate value at the first count. Hard seed germination shows a sudden increase at the third count, while by the fourth it is practically at its maximum.

In Plot No. 2 Lacombe (Table 11C) the hard seeds show a fairly high initial germination, which rapidly increases almost to the maximum by the second count. Much the same is true in the third plot at Lacombe (Table 11 D), except that here the hard seeds have relatively a much higher value than in the other plots. In this plot an unusual point is that the highest relative value of hard to permeable seed occurs, not at the last count but at the last but one, though both kinds show increased field germination.

Since in Alberta sweet clover is not expected to give a crop the same year as sown, all germination produced during the season may tentatively be considered as of agricultural value, till it has been determined by the 1928 check-up what plants have survived the winter. In Table 12 is shown the relative agricultural value of the impermeable seeds as apparent at the end of the season.

TABLE 12.—*Agricultural value of hard seeds as shown at the end of the season.*

Plot	Ag. Val. H. S. where P. S. = 100
Brooks	50.8
Lacombe No. 1	32.9
Lacombe No. 2	61.2
Lacombe No. 3	77.5
Average	55.6

Lacombe Plot No. 1 shows the lowest value for the hard seeds. It was previously mentioned that this plot suffered somewhat from the effects of cutworm; in fact, cutworm was present in the other Lacombe plots to a slight extent, but not as much as in No. 1. Since the germination of the permeable seeds has been shown to be more prompt than that of hard, and since cutworms would naturally attack the earlier seedlings at a time when their food supply was scarce, it would be expected that seedlings from the permeable seeds would suffer most, and might be lost. That this however, does not appear to be the case is seen from the fact that in this plot the hard seeds do not show an abnormally high value. We may conclude therefore that the presence of cutworm has not materially affected the value of this plot from an experimental point of view.

An interesting point is suggested by this table. In the three plots which, being in the same district, can be directly compared, the hard seeds are seen to have a relatively higher value, the later the seeding. This may or may not be significant, but appears to be related to the effects previously reported

with alfalfa, in which germination of hard seeds was apparently favoured by warmth and absence of excess of soil moisture.

Plot No. 3 Lacombe remains somewhat of an enigma as there appears to be no reason why the germination of this plot should average lower than the other two. A comparison of the average temperature and moisture conditions in these three plots shows little marked differences; in fact the moisture conditions are rather uniform, while the mean temperatures for corresponding periods average higher for this plot. Cutworm as previously stated was not serious in this plot.

A check-up after the final count shows that there has been a very high mortality during the season among all the plots. Data on this point are given in Table 13.

Table 13.—*Mortality of plants during the season.*

Plot	Average per cent total germination	Average per cent plants lost	Relative loss per cent
Lacombe No. 1	28	18	64.3
Lacombe No. 2	34	14	41.2
Lacombe No. 3	23	7	30.4
Brooks	54	9	16.7

A comparison of the relative mortality of any plot with the average meteorological conditions prevailing during the season for that plot shows a correlation between favourableness of conditions and lowness of observed mortality.

The season was an unfavourable one in any case, owing to the comparatively high precipitation and low temperature. At Brooks, however, a much drier and warmer district, the germination is markedly higher, so that it seems that the rather irregular results at Lacombe must be ascribed to the particular meteorological conditions prevailing at the time.

It appears to be impossible to make a sweeping generalization as to the relative agricultural value of hard seeds of sweet clover, since in this year's work considerable variation has existed under the four different sets of conditions under observation. Multiplication of results in a number of districts and covering several years would be needed to establish a reliable working guide; but since the variations would continue to exist, it seems justifiable to conclude that about 50% represents the average agricultural value of hard seeds in *Melilotus alba* as shown *to date* in this year's work, and it is possible that this value may not be much changed by subsequent investigation.

The check-up in the spring of 1928 should, however, constitute a more reliable basis, since it is quite possible that some of the hard seeds will germinate after the winter (Harrington *1*).

Section IV.

When the equation method described in Section III was devised, it was felt that it might profitably be employed on the experimental results of 1925 and 1926. A second thought however, showed that this was impossible with respect to the 1926 field work, since the samples used that year were not average samples such as might be received in the trade, but were largely

artificially prepared, as has already been described. Interpretation of the results obtained, however, was not difficult and has been discussed.

With regard to the 1925 work, interpretation was difficult, but application of the equation method, (so called for want of a better term) has thrown much light on it.

Table 14 shows the progressive field germination of the hard and permeable seeds and the progressive relative value of the hard seed.

TABLE 14.—*Progressive field germination of the hard and permeable seeds.*

	Count No.	Field Germ. Hard Seeds	Field Germ. Perm. Seeds	Ag. Val. H.S. where P.S.=100
A. Lethbridge Irrigated	1	14.0	33.8	41.4
	2	24.9	41.4	60.1
	3	27.7	43.1	64.2
	4	30.5	44.3	68.9
	5	30.9	44.4	69.6
B. D.I.E.S. Brooks	1	23.9	43.5	55.0
	2	34.7	44.5	77.7
	3	38.6	47.0	82.2
	4	39.5	47.4	83.3
	5	40.0	47.3*	84.5
C. Brooks C.P.R. Plot	1	49.7	31.4	--
	2	36.8	50.8	72.4
	3	40.7	52.7	77.3
	4	41.3	52.7	78.4
	5	41.2*	52.9	77.9

* This apparent reduction in germination must be due to a slight cumulative error introduced by the use of logarithms.

In the Lethbridge irrigated plot (Table 14 A) there is a gradual increase in the field germination of both the permeable and hard seeds, but to a more marked extent in the latter. The relative value of the hard seeds increases also from the first count, abruptly to the second, and more gradually thereafter. The same holds true in a general way in the case of the D.I.E.S. plot at Brooks (Table 14 B).

In examining the figures for the C. P. R. Brooks plot (Table 14 C), it is to be seen that count No. 1 is entirely out of line with the rest. Referring to the table of field results it will be noticed that sample No. 4957 at this count germinated much less with respect to its performance in subsequent counts, relatively, than the remaining samples. This sample had high laboratory germination and a very low percentage of hard seeds; hence, this low performance at this count has had the effect of unduly exaggerating the value of the hard seeds. In computing by the method of least squares p has been given the value of 1 for all samples in this plot. Letting $p = \frac{1}{2}$ for this sample in this first count, the hard seeds have a field germination of 44.0% and the permeable of 37.4%. This result confirms the foregoing statement. It is very difficult to know just what value to give to p. There is no reason why at this count the results should be less reliable than at subsequent counts in this plot, on the sample in question. It is felt best, however, to ignore this count.

Since alfalfa is a perennial crop, we may tentatively consider that all seeds germinating to the end of the season are of agricultural value. On

this basis then we find that as an average of the 1925 results with alfalfa, the hard seeds have approximately 77% of the value of the permeable.

Some further light is thrown, however, by the analysis of the results of the check-up on the D. I. E. S. plot at Brooks, in the early part of 1926. Since these figures have not previously been reported, they are given here in Table 15, together with the standing of the plot at the final count in the fall of 1925.

TABLE 15.—*Plants surviving after first winter, D.I.E.S., Brooks.*

Sample No.	Final Count, 1925	Check-up, 1926
205	37	36
206	33	32
908	40	35
1648	60	59
4562	46	40
4740	51	45
4957	33	26
5339	45	32

Analysis of these figures by the equation method gives us the results tabulated in Table 16.

TABLE 16.—*Field germination of the hard and permeable seeds in the Brooks Plot, 1925 (D.I.E.S.)*

Count	Field Germ. Hard Seeds	Field Germ. Perm.. Seeds	Ag. Val. H.S. where P.S. = 100
Final, 1925	40.0	47.3	84.5
Check-up, 1926	37.8	40.1	94.3

The seedlings produced by the hard seeds showed a net loss of 2.2%, those by the permeable seeds a net loss of 7.2% as a result of wintering over. The relative agricultural value of the hard seeds shows an increase of 9.8%.

Thus from the point of view of germination and survival value the hard seeds are very nearly on a parity with the permeable in this plot.

It is unfortunate that this check-up was not done as originally intended on all the plots, but at the time it seemed as if little could be gained from it, (the present method not having been devised) and owing to pressure of other work, it was dropped.

This result is of particular interest when compared with the observations on the scarified samples (Nos. 7 and 8) of the 1926 work on alfalfa. The plants produced by these samples were noticeably paler and less vigorous than the remainder in the Brooks plot, as mentioned in the Section covering that year's work.

In 1925, of the four plots planted, one was in a district requiring irrigation, but received no irrigation in order to see how the hard seeds behaved under such conditions. The resulting germination was so low that it was not considered that this plot could be of any value. Nevertheless, it was thought that it might be of interest to apply the equation method to this plot. This was done for the final count, and showed the hard seed to have a field germination of 22.3%, while the permeable only showed 2.6%. Thus in this plot the permeable seed only had 11.5% of the value of the hard.

While the figures should not be taken too literally on account of the difficulty of assigning suitable values to p, particularly in the case of results which are so low that they tend to be unreliable, and to exaggerate differences unduly, it is interesting to note that in this plot, where the conditions were very adverse to the successful germination of alfalfa seed, both on account of the unsatisfactory state of the tilth and of drought conditions, the hard seeds show a great advantage over the permeable.

Summary

(1) The question has arisen as to the agricultural value of those seeds of clover and alfalfa which remain impermeable or "hard" during the germination test. This report covers three years' work, two with alfalfa (the variety Grimm being used) and one with sweet clover (*M. alba.*).

(2) From the two years' investigation on alfalfa it was concluded that the hard seeds had practically the same value from the point of view of the number of plants produced as had the permeable.

(3) Heavy scarification was shown to be detrimental to field germination.

(4) Permeable seeds in alfalfa gave more prompt germination but the hard seeds caught up by about the middle of the summer.

(5) In alfalfa the hard seeds appeared to produce plants which were more winter-hardy than those produced by the scarified.

(6) Hard seed germination appeared to be favoured by limited soil moisture and high temperature.

(7) Very few seeds of alfalfa germinated after wintering over in the plots, but their number was quite insignificant.

(8) A new mathematical method for computing the most probable values for the field germination of the hard and permeable seeds is described. The investigation on sweet clover was planned in the light of this method.

(9) Permeable seeds of sweet clover were shown to give more prompt and more complete germination than the hard. Nevertheless the latter rapidly increased to their maximum germination which, however, averaged only about fifty per cent of that of the former.

(10) Hard seeds in sweet clover were shown to have a higher relative value the later the date of seeding in the district (Lacombe) in which three plots were seeded at intervals.

(11) The later the date of seeding at Lacombe, the less was the mortality in the plots. At Brooks where the conditions were more favourable the relative mortality was least.

(12) The results for 1925 were re-examined in the light of the equation method.

(13) This showed the relative value of the hard seeds of alfalfa to vary from 70% to 85% at the end of the first season.

(14) In the plot in which the hard seeds had a value of 85%, this value increased to 94% after wintering over though additional germination was practically negligible. This confirms the observation in section 5 of this summary.

Thanks are due to the staffs of the Dominion Irrigation Experiment Station Brooks, the Dominion Experiment Stations at Lacombe and Lethbridge, the C.P.R. Experimental Farm, Brooks; also to Mr. P. M. Ballantine, Lacombe, from all of whom cordial co-operation and assistance have been received.

Acknowledgement is also due to Mr. G. M. Stewart, District Inspector, Seed Branch, Calgary, for co-operation and suggestions in the early part of the investigation and for the securing of samples each year; also to Mr. A. Hope, Senior Analyst, Seed Branch, Calgary, who has been responsible for the entire handling of the field work.

Illustrations

Figures 2, 3, 4 and 5 show the performance of some of the alfalfa samples at the D.I.E.S. plots. Photographs by courtesy of Mr. W. L. Jacobson, Irrigation Specialist.

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COMPARATIVE STUDY OF STRAINS OF MARQUIS WHEAT.

In view of recent corrections of a former statement made by a member of the staff of the Cereal Division, Ottawa, regarding the origin of Marquis, Ottawa 15, my paper appearing in the October issue of this journal under the above title should be corrected as follows: On page 79, line 7 should read: "of the 15 strains only 3, Nos. IV, VI, and XII, are known." On page 104, the third sentence under Strain XIII should read: "Originated by bulking together a number of lines which were selected from the original Marquis, and appeared identical."

(Signed) J. B. Harrington.

FIGURE 2. Sample No. 3, machine-threshed seed, from which the hard seeds had been separated by the blotter method. (Representing 100% hard seeds.)

FIGURE 3. Sample No. 5, untreated but machine-threshed. (33% hard seeds.)

FIGURE 4. Sample No. 6, hand-rubbed. (70% hard seeds.)

FIGURE 5. Sample No. 8. Scarified. (Representing 0% hard seeds.)

NOTES

PARALYSIS AND RATION DEFICIENCIES

H. R. Hare

[Received for publication November 10, 1927]

The importance of minerals and vitamins in livestock nutrition is rapidly becoming recognized. Much of the livestock in present day agriculture is raised by highly artificial methods. Animals removed from their natural feeding environment frequently develop unthriftiness or become diseased, due to reduced vitality produced by rations lacking in suitable or sufficient mineral and vitamins. In early maturing animals, such as hogs, ration deficiencies express themselves more readily than in other farm animals.

The feeding of hogs at the University of British Columbia is carried on without pasture. This is an unnatural condition. Though pasture substitutes have been provided by the use of soiling crops, alfalfa hay and minerals, nutritional difficulties have not been entirely avoided.

The accompanying picture shows both sides of the split spinal column of an eighteen months old Yorkshire sow. This sow farrowed at approximately one year of age with a litter of ten. She milked heavily, became quite thin, but weaned nine good pigs. Two days after weaning she suddenly developed paralysis of the hind quarters. She would drag herself

A split section of the back bone of a sow which was paralized in the hindquarters. The post mortem revealed that the 5th lumbar vertebra was fractured and that the neural canal had become restricted, causing pressure on the spinal cord and resulting in paralysis.

around the pen, but would eat little. Anticipating the cause of the paralysis, she was slaughtered by the College veterinarian and post mortem examination revealed that the fifth lumbar vertebra had been fractured. When the vertebra had thus collapsed it pressed on the spinal cord acting as a nerve block which caused sudden posterior paralysis. The picture shows the shattered vertebra, the restricted neural canal and congestion behind the seat of the trouble. Kidney worms have often been blamed for such paralysis, but no evidence of such were found in the post-mortem.

The Ohio and other experimental stations have made several investigations in connection with vitamin and mineral dificient rations with hogs. At the Ohio Station conditions similar to that here quoted have been produced by feeding grain rations deficient in minerals and vitamins.*

The grain ration of the sow in question always contained 2 per cent of spent bone black as well as some tankage. The mineral elements were thus supplied in adequate amounts. The deficiency seems to have been in the vitamin content of the ration. The sow received optimum amounts of skim-milk up to 6 months of age when she was placed in a run quite bare of pasture but was fed some alfalfa hay along with ground grains. It is quite possible that the alfalfa hay fed failed to provide the amount of vitamins necessary for the proper assimilation of the minerals which were provided in the ration.

University of British Columbia,
Vancouver, B.C.

BOOK REVIEW

The Book of Bulbs, by F. F. Rockwell, (The Macmillan Company of Canada, Toronto, Ontario, 1927. $3.50.)

This book is published at an opportune time, for bulb growing in Canada has steadily increased in popularity during the past ten years, and there is every indication that it will continue to increase in the years to come.

In the title, the word "bulbs" is used in its widest possible sense, for it includes not only the true bulbs, such as the tulip, hyacinth, daffodil, lily, etc., but also the peony, iris, gladiolus, dahlia, and a host of others.

The book is written with three purposes in view:— (1) to show the reader what enchanting effects may be obtained with bulbs as subjects for general use, (2) to stimulate a greater interest in this exceedingly useful class of plants, and (3) to give brief but comprehensive suggestions as to cultural requirements.

These purposes have been fulfilled with outstanding success, for the subject matter has been expressed with a thoroughness of detail which shows an intimate and wide knowledge of the subject, in a readable style, and with excellent illustrations.

The publishers have contributed largely to the success of the book by an excellent reproduction of cuts and photographs and by the use of high quality type and paper.

The amateur with his small garden, the advanced horticulturist, the professional and the commercial grower should all possess a copy of this book, for they can obtain, in an entertaining way, expert advice on this most interesting subject, based on wide and sound practical experience. F. L. D.

*Bohstedt, G., Bethke, R. M., Edington, B. H. and Robinson, W. L. Bul. 395, Ohio Agr. Exp. Sta.

LA COMMISSION INTERNATIONALE POUR L'ETUDE SCIENTIFIQUE DES ENGRAIS*

Cet organisme a été fondé à Rome, au siège de l'Institut international d'Agriculture, sur la proposition de Monsieur Villegas, ambassadeur du Chili et délégué au comité permanent de l'Institut.

En 1922, Monsieur Villegas présenta un rapport très élaboré sur la production et la consommation des engrais en général, et suggéra un projet d'organisation d'un système d'expériences avec engrais, concerté entre les différents pays, exécuté suivant des règles scientifiques uniformes, standardisées et parfaitement comparables.

Le succès de cette proposition était assuré d'avance par l'existence d'un cadre de techniciens travaillant dans le monde entier et représenté par l'ensemble des délégués des producteurs de nitrate de soude du Chili.

On sait, en effet, que ces délégués, choisis parmi les agronomes les plus compétents, par l'Association des producteurs de nitrate, sont, depuis nombre d'années, chargés de faire de la propagande par l'expérimentation.

Répondant à ces vues, Monsieur de Michelis, président de l'Institut international d'Agriculture, convoqua les délégués des producteurs de nitrate à une conférence tenue à Rome, le 11 septembre 1925. Le comité permanent de l'Institut international décida, au cours de cette réunion, ne nommer une commission internationale chargée d'élaborer et d'exécuter le programme des travaux en perspective. Ainsi fut fondée la "Commission internationale pour l'étude scientifique des engrais", qui représente le premier organisme faisant partie du "Comité de recherches Scientifiques internationales", créé au sein de l'Institut International d'agriculture.

Cette commission internationale des engrais se réunit pour la première fois, à Rome, du 9 au 13 février 1926; elle régla dans le détail les observations et essais à faire sur les engrais et proposa l'établissement d'un contrôle international sur les engrais.

Parmi les membres de la commission, représentant chacun un des pays adhérants il y a à mentionner:

Prof. Lemmermann, de l'Ecole Supérieure d'agriculture de Berlin (Allemagne).

Sir John Russell, Dr. Sc. F.R.S., Directeur de la Station expérimentale de Rothamsted (Angleterre).

Prof. M. A. Grégoire, Directeur de la Station agronomique de l'Etat, à Gembloux (Belgique).

M. Alejandro Bertrand, Ingénieur civil des mines (Chili).

Prof. Dr. Harold Christensen (Danemark).

Prof. J. G. Lipman, Recteur du Collège d'agriculture du New Jersey (Etats-Unis).

Dr. Jannes, de Helsingfors (Finlande).

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* Ces notes ne sont qu'un résumé du rapport detaillé paru dans la Revue Internationale des renseignements agricoles, concernant l'historique de la fondation de la Commission Internationale pour l'étude scientifique des engrais, et les travaux de sa première réunion tenue à Rome, en mois de février 1926. H.M.N.

M. Roux, Directeur des Services sanitaires et scientifiques du Ministère de l'agriculture, Paris (France), représenté par monsieur Bruno, Inspecteur général des Stations agronomiques, Paris.

Prof. Angelo Menozzi, Directeur de l'Ecole supérieure d'agriculture, de Milan (Italie).

Dr. D. Knuttel, Directeur de la Station agronomique de Maastricht et Prof. J. H. Aberson, de l'Université agricole de Wageningen (Hollande).

Prof. Prianichnikov, Université de Moscou (Russie).

Prof. C. A. H. von Feilitzen, Directeur de la Station centrale d'expériences agricoles, de Stockholm (Suede).

Prof. Wiegner, du Polytechnikum, de Zurich (Suisse).

Prof. J. Stoklasa, Directeur de la Station de chimie et de physiologie végétale, de Prague.

Dr. Ing. Jan Jelinek, de l'université agricole et forestière de Prague (Tchékoslovaquie).

Elaboration du Programme de la Commission

La séance d'inauguration de cette première conférence internationale pour l'étude scientifique des engrais fut ouverte le 9 février 1926, à 10 heures du matin, sous la présidence de S. E. Michelis, président de l'Institut, qui, après avoir adressé les compliments d'usage à l'assemblée, souligna l'importance de la nouvelle association dans l'œuvre de coordination internationale des recherches scientifiques agricoles que l'Institut de Rome tend constamment à réaliser avec la collaboration des agronomes de monde entier.

Ensuite le président de la conférence exposa le projet de programme, tel qu'il avait été préparé d'avance pour être discuté au cours des séances de la journée et des jours suivants. Ce programme comportait trois chapitres principaux :—

1o *Plan d'une organisation internationale pour les essais comparatifs des engrais chimiques.*

2o *Standardisation des expériences sur les engrais chimiques.*

3o *Contrôle du commerce des engrais chimiques.*

En ce qui concerne la première et la deuxième question, qui sont inséparables l'une de l'autre, puisqu'on ne peut concevoir un plan international d'expériences comparatives sans y inclure la standardisation ou uniformité conventionnelle des essais, monsieur de Michelis déclara que, se basant sur les études préliminaires faites a l'Institut, les règles d'après lesquelles les expériences devraient être conduites dans le plan international, porteraient sur les points suivants, qui demandaient à être parfaitement developpés:

1) La dimension des parcelles;
2) Nombre des parcelles pour chaque essai;
3) Distribution des parcelles dans chaque essai;
4) Nombre d'essais pour chaque série d'expériences;
5) Fixation des types de terrain pour chaque série, de façon à éliminer la variable "terrain";
6) Fixation des zones climatiques pour chaque série, de façon à éliminer la variable "climat";

7) Nombre d'années ou d'assolements pendant lesquels on doit répéter les épreuves;
8) Plantes types à choisir pour les essais;
9) Règles pratiques pour la préparation des parcelles, la manutention et la récolte des données.

D'autre part, le président émit l'opinion qu'il conviendrait de mettre en premier lieu au programme du plan international la question des engrais azotés, tant en ce qui concerne les formes classiques de fertilisants, tels que le nitrate de soude, le sulfate d'ammoniaque et la cyanamide de calcium, que diverses formes de composés synthétiques nouveaux qu'on trouve actuellement sur le marché. Après cela viendrait l'étude des engrais phosphatés et principalement la solution du problème de la forme la plus avantageuse sous laquelle on peut utiliser le phosphate de calcium. Enfin, dans les expériences concernant les engrais potassiques il y aurait notamment lieu de porter l'attention sur l'emploi des silicates potassiques assimilables, dont l'Italie possède d'immenses gisements encore inexploités.

Les différents points du programme ainsi tracé furent discutés et développés par les membres de la nouvelle Commission internationale, au cours de plusieurs séances qui occupèrent les quatre jours que dura la première Conférence internationale pour l'étude scientifique des engrais, pour arriver aux résolutions et conclusions suivantes, qui se trouvent résumées dans le rapport présenté par monsieur Cordoso, et adopté à l'assemblée de clôture de la conférence, le 13 février 1927:

1o *Plan d'organisation internationale pour les essais comparatifs d'engrais chimiques:*

1) La commission émet le voeu que les travaux relatifs aux études sur les matières fertilisantes soient continués par l'Institut international d'agriculture au moyen des ses organes compétents, de la Commission qu'il a nommée à cet effet et qui pourra être convenablement élargie; et que les travaux à publier sur cette question soient inclus dans la Revue internationale de renseignements agricoles publiée par l'Institut.

2o *Standardisation des expériences sur les engrais chimiques:*

1) Sol: Choisir un sol aussi uniforme que possible, et le contrôler par un assez grand nombre de sondages: couche arable jusqu'à........ cm; sous-sol jusqu'à .... cm. Eviter les terrains en pente notable, surtout en sol peu perméable. S'il faut employer un sol incliné, tracer des parcelles rectangulaires allongées perpendiculairement au thalweg.

2) Formes des parcelles: S'inspirer des possibilitiés du terrain et des autres conditions locales pour tracer des parcelles carrées ou rectangulaires.

3) Surface des parcelles: Donner à chaque parcelle au minimum 25 mètres carrés et au maximum 100 mètres carrés.

4) Nombre de parcelles: Répéter le même essai au moins 5 fois, et avoir au moins 5 terrains.

5) Distributions des parcelles: Les répartir uniformément suivant les dimensions et la disposition du terrain.

6) Passages entre les parcelles: Les parcelles sont contingues, sauf à laisser dans une seule direction un passage de 50 centimètres de large, de 2 en 2 parcelles, pour faciliter les soins culturaux, et l'inspection. L'ensemencement couvre uniformément toute la surface du champ. Pour la récolte, on supprime d'abord les plantes sur une largeur de 50 centimètres en dedans des limites tracées pour chaque parcelle. Les essais sont donc toujours séparés les uns des autres par une distance de 1 mètre sur 3 côtés et de 1.5 mètre du côté du passage.

6a) Distribution des engrais: Les engrais doivent être appliqués avec exactitude et régularité, une attention spéciale étant donnée à l'application du fumier de ferme. Chaque engrais sera appliqué en moment opportun pour sa bonne action, en une ou plusieurs fois.

7) Durée des essais: Prolonger le contrôle des mêmes surfaces pendant 5 années au moins sur la succession des cultures.

8) Caractéristiques de sol et de climat: Les noter et les publier avec les résultats: Sol: localité, profondeur, analyse (méthodes de l'Association Internationale de la science du sol); climat: température, nébulosité, pluie: quantité et nombre de jours; neige; actinométrie.

8) Composition des engrais: Donner toujours l'indication précise des engrais employés: nature,origine, finesse, analyse chimique complète, et éventuellement caractères pétrographiques et microbiologiques.

9) Plantes employées: Utiliser toujours des semences bien controlées, indiquer leur qualité, la densité du semis. Bien préciser la variété et l'origine.

10) Remarques sur la végétation: Noter les faits essentiels de la végétation, leurs dates. Attaque de maladies ou de parasites. Mauvaises herbes. Traitements à appliquer. Accidents ou dégats causés par des facteurs météorologiques ou des causes fortuites.

11) Récolte: Il est recommandé d'exprimer toujours les résultats en matière sèchée à l'air et en substance sèche (à 100°).

11a) Erreur expérimentale: L'expérience sera considérée comme démonstrative lorsque les différences des moyennes des résultats obtenus seront au moins le double de l'erreur probable.

11b) Fermes expérimentales: La commission estime recommandable d'établir dans chaque région naturelle une ferme expérimentale soumise au contrôle direct de laboratoires des différentes spécialités coopérant au perfectionnement de l'agriculture.

3o *Contrôle du commerce des engrais chimiques.*

La commission tout en estimant impossible d'arriver a bref délai à un accord international pour unifier les méthodes d'analyse des matières fertilisantes, croit cependant pouvoir recommander pour les transactions internationales, l'unification du mode d'expression des résultats d'analyse, notamment:

Pour les engrais azotés, expression en azote (N) et non NH_3 pour 100 kilogrammes, en indiquant la forme de l'azote. Pour les engrais phosphatés, expression en P_2O_5 et non en phosphate tricalcique, avec indication de solubilité dans les réactifs spéciaux. Pour la potasse expression en K_2O, et solubilité dans l'eau, ou dans un réactif de composition indiquée.

Les chiffres donnés seront obligatoirement accompagnés de l'indication de la méthode d'analyse employée.

Programme de la Prochaine Reunion de la Commission Internationale pour l'Etude Scientifique des Engrais.

Avant de se séparer, les membres de la commission adoptèrent aussi le programme des rapports à préparer pour la prochaine réunion. En voici la liste, avec les noms des rapporteurs:

1) Instruments spéciaux pour l'exécution d'expériences culturales. M. le Professeur Grégoire (Gembloux, Belgique).
2) Climat sec et engrais. M. le Professeur Quintanilla (Madrid, Espagne).
3) Choix du sol d'expérience, sondage, examen et réaction de l'échantillon. M. le Professeur Christensen (Danemark).
4) Présentation des résultats des expériences culturales; standardisation; fiches; diagrammes; M. le Professeur von Feilitzen (Suède).
5) Application pratique des expériences, M. le Professeur Menozzi (Italie).
6) Expériences sur l'effiicacité relative et la rentabilité des fumures. Professeur Lemmermann.
7) Etude critique des législations et systèmes de contrôle du commerce des engrais chimiques en usage dans les différents pays. M. le Professeur Jellinek (Tchékoslovaquie).
8) Etude critique des méthodes d'analyse des matières fertilisantes en usage dans les différents pays. M. Bruno (France).

H. M. N.

ACTIVITES DES SECTIONS

Section de Montreal

Le grand banquet annuel qui parait bien être passé au rang de tradition dans la section de Montréal depuis que l'exposition de pommes et certains autres évènements agricoles amènent le passage d'un grand nombre de techniciens et personnalités du monde agronomique dans la métropole du Canada. au cours de la première moitié de novembre, a eu lieu le jeudi 10 de ce mois, à 7.30 p.m. à l'hôtel du cercle universitaire, 361 rue Sherbrooke est. Les tables étaient dressées dans la spacieuse et belle salle nouvelle, tout récemment inaugurée par l'administration du cercle universitaire qui en ces dernières années a pris un essor dépassant les prévisions les plus optimistes. La réunion fut présidée par M. L. Ph. Roy, chef du Service de la Grande culture à Québec et président général de la C.S.T.A. Comme hôte d'honneur, il y avait l'Honorable L. Perron, ministre de la Voirie de la province de Québec, et monsieur Gustave Toupin, professeur à l'Institut Agricole d'Oka, fut le

principal conférencier. A la table d'honneur on remarquait en outre: Le Très Révérend Dom Pacôme Gaboury, Abbé de La Trappe d'Oka; Mgr. Vincent Piette, Recteur de l'Université de Montréal; monsieur J. Antonio Grenier, Sous ministre du département de l'agriculture de Québec; le Dr. Théodore Gervais, membre de la Chambre des Communes, messieurs J. W. Gagnon et Charbonneau, députés à la législature provinciale; Aldéric Lalonde, et l'abbé Picotte, respectivement Président et Aumônier général de l'Union Catholique des cultivateurs de la province de Québec; Narcisse Savoie, Chef du Service agronomique de la province; W. H. Brittain, président de la section Macdonald de la C.S.T.A., Aimé Gagnon, professeur à l'Institut Agricole d'Oka; H. M. Nagant, président de la section de Montréal et Fred. Grindley, secrétaire général de la C.S.T.A.

Au dessert, Monsieur L-Ph. Roy se leva pour souhaiter la bienvenue à l'Honorable ministre Perron, dont il fit ressortir la forte personnalité et la féconde activité dans cet important département de la Voirie, dont les réalisations offrent tant de points d'intérêt communs avec ceux de l'agriculture. Il le remercia aussi chaleureusement au nom de tous les techniciens agricoles présents pour avoir bien voulu distraire cette soirée d'un temps précieux et sollicité de tous côtés, et venir rehausser de sa présence notre réunion professionnelle. Après avoir encore adressé une cordiale bienvenue et un mot aimable à chacun des autre hôtes présents à la table d'honneur, monsieur Roy donna la parole au confrère Gustave Toupin, qui traita de la nécessité d'une puissante diffusion de l'enseignement agricole dans la province de Québec.

"Ceux qui ont conseillé, dit-il, dans les dernières années, à nos cultivateurs et à leurs fils de ne pas quitter le sol ont reçu d'eux cette réponse exempte de tout équivoque; pour mieux nous attacher à la terre, rendez-en la culture payante. Formule claire, démontrant bien qu'il faut aujourd'hui plus que des arguments d'ordre sentimental pour retenir les nôtres sur le sol. Rendre à nos ruraux la culture suffisamment payante, non seulement pour y trouver le pain de chaque jour, mais pour pouvoir en retirer assez de revenus pour vivre sous un toit confortable; assez de revenus pour donner aux enfants une bonne instruction et leur procurer une vie agréable; assez de revenus même pour réaliser les épargnes nécessaires durant les mauvais jours; est la principale condition de l'attachement des nôtres au sol".

Pour rendre la culture plus payante, dit M. Toupin, il y a quatre remèdes à prescrire: l'organisation systématique de la production de la ferme; la création d'un système de crédit agricole, l'association professionnelle et la formation d'un esprit de coopération. C'est de ce premier remède qu'a parlé le conférencier. Il traita au long de la nécessité de l'organisation systématique de la production sur la ferme. D'abord, organiser systématiquement la production sur la ferme, c'est y adopter les meilleures méthodes de culture, aux fins de produire en quantité et en qualité et de la façon la plus économique les denrées qui ont le plus de chance de trouver en permanence un débouché sûr. En tenant compte des facteurs économiques déterminant un système de culture, à savoir: sol, climat, main-d'oeuvre, marché, l'on doit admettre que ce sont surtout les produits animaux qui doivent intéresser la masse de nos cultivateurs parce que ce sont encore ceux-là qui trouvent de plus vastes débouchés. Les produits animaux sont, par exemple, le lait, la

chair, les oeufs etc. Ceci a amené le conférencier à parler des moyens d'augmenter cette production et d'une manière rationnelle. C'est à proprement parler les méthodes qu'enseignent nos agronomes afin de détruire les méthodes anciennes faites de routine.

Il y a eu de grands progrès, mais notre agriculture est encore à la période empirique de son histoire. Toutefois, depuis quinze ans, les agronomes ont essayé de démontrer la valeur économique de la science agricole, et ils y ont assez bien réussi. Le gouvernement y a coopéré dans la plus large mesure et aidera de plus en plus à la diffusion de l'enseignement agricole. Il y a des revisions à faire dans les programmes: le gouvernement aidera nos écoles d'agriculture à réaliser ce vaste programme.

L'Honorable M. Perron, qui prit la parole après la conférence de M. G. Toupin, commença par rendre un bel hommage à l'oeuvre de monsieur le ministre Caron, qu'une indisposition empêchait d'assister au banquet. "Si la province de Québec, dit-il, possède un classe d'agronomes qui lui font honneur, c'est dû à l'initiative de l'honorable monsieur Caron". Il adressa aussi des félicitations à monsieur Gustave Toupin pour la conférence aussi intéressante qu'instructive qu'il venait de faire, puis ne touchant que d'un mot les rapports qui existent entre un bon système de voirie et les intérêts de l'agriculture, l'orateur démontra amplement qu'il était aussi très bien au courant des grands problèmes agricoles de la province. Le ministre de la voirie déclare qu'il s'est toujours intéressé à l'agriculture. Du reste, il est profondément attaché à la classe agricole dont il est sorti lui même.

Il lui fait plaisir d'avoir à ses côtés le T. R. P. Dom. Pacôme, abbé de la Trappe d'Oka. Il le connait depuis très longtemps, ayant eu le plaisir d'être compagnon de classe avec lui au collège. C'est l'un des plus beaux talents qu'ait possédé l'institution où il a étudié. Il est heureux que le R. P. abbé soit à la tête d'une des plus importantes institutions agricoles de la province.

"La profession d'agronome, dit l'honorable M. Perron, est la plus importante qui soit à l'heure actuelle. Les agronomes ont à exercer un apostolat. Si tous les agronomes possèdent la compétence de technicien, la province en bénéficiera".

En terminant le ministre de la voirie demande à tous les agronomes de vulgariser la propreté dans les campagnes. Il faudrait inculquer à nos cultivateurs de tenir leurs fermes dans un état irréprochable de propreté non seulement pour éloigner toute cause de maladie contagieuse mais pour montrer aux étrangers qui nous visitent que les fermes de la province de Québec sont parfaitement tenues. L'agronome doit conseiller aux agriculteurs d'embellir leurs fermes.

Le professeur W. J. Brittain, qui fut l'orateur suivant, apporta le salut de la section du collège Macdonald à ses confrères français. Faisant aussi entièrement sienne la thèse du professeur Toupin en faveur d'une diffusion plus grande de l'enseignement agricole en général et de l'agrandissement des écoles d'agriculture devenues trop petites pour satisfaire à la demande toujours croissante de cours abrégés et de cours d'hiver; il fit remarquer que ce besoin ne devait pas faire perdre de vue la nécessité première d'un enseignement agricole scientifique et de travaux de recherche parfaitement organisés.

L'efficacité et le progrès de l'enseignement agricole moyen et pratique sont, en effet, sous l'étroite dépendance de l'enseignement supérieur, qui doit en être la source première, l'inspirateur éclairé; l'étude, la recherche et l'expérimentation doivent précéder la démonstration et l'application pratique si on veut que celles-ci ne s'enlisent pas dans les sentiers de la routine et de l'empirisme.

Mgr. Piette, recteur de l'Université de Montréal, eut aussi des phrases très aimables pour les agronomes tout en assurant à l'enseignement agricole toute l'estime et la sollicitude de l'université.

Enfin, le professeur Aimé Gagnon, en une spirituelle improvisation, adressa les remerciements de l'assemblée aux deux principaux orateurs du banquet, dont la clôture fut prononcée vers 11 hrs. p.m.

La présence de 84 convives fut, ce nous semble, la meilleure preuve que le succès des diners-causeries organisés depuis plusieurs années dans les sections de la province de Québec de la C.S.T.A. bien loin de ralentir, ne fait que croitre.

H. M. N.

Section de Ste. Anne de la Pocatiere

Banquet à Rimouski

A l'occasion de la Convention de l'Industrie latière, la section de Ste. Anne organisait un banquet à Rimouski, le 16 novembre, Mons. J. A. Ste-Marie, Président de la Section de Ste-Anne et Régisseur à la Station Expérimentale, offre, au nom de la section, des félicitations à Mons. L. Ph. Roy pour sa nomination à la présidence générale de la C.S.T.A. Il souhaite également la bienvenue à Messieurs les abbés Belzile et Saindon de l'Ecole d'Agriculture de Rimouski, ainsi qu'à Mons. Georges Marquis, Chef du Bureau des Statistiques de la province de Québec.

Mons. L. Ph. Roy, Président général, et Chef du Service de la Grande Culture, parle de la dernière convention annuelle et de la Revue Agronomique. Il nous rappelle aussi que la prochaine convention annuelle de la C.S.T.A. aura lieu à Québec en juin; on compte recevoir au- delà de 500 délégués qui visiteront Québec, l'Ecole d'Agriculture et la Station Expérimentale de Ste-Anne. En terminant, Mons. Roy remercie les membres de lui avoir fait l'honneur de l'élire à la présidence générale de la C.S.T.A. et promet de faire tout en son pouvoir que la convention de juin 1928 remporte un franc succès.

Mons. Georges Marquis, Chef du Bureau des Statistiques, fait remarquer que dans un quart de siècle, grâce aux connaissances techniques, nous aurons fait plus de progrès que durant les 150 dernières années. En terminant il dit aussi que nous devons compter beaucoup sur les techniciens pour avoir des chiffres fournissant des renseignements sûrs et précis pour la compilation des statistiques.

Mons. Narcisse Savoie, Directeur du Service des Agronomes, demande à tous les membres de mettre l'épaule à la roue afin que la convention annuelle de juin soit mémorable dans les annales de la C.S.T.A., et de nous

organiser de manière à faire connaitre à nos amis des provinces voisines ce que c'est que la gaité gauloise.

B.B.

Notes

Nous apprenons que Mons. Rosaire Proulx, Assistant Régisseur à la Station Expérimentale de Ste-Anne de la Pocatière, a été promu à la position de "Surveillant des Fermes de Démonstration de l'Est, en remplaçement de Mons. J. Harry Tremblay".

Mons. H. N. Racicot, Pathologiste préposé au Laboratoire de Pathologie végétale de Ste-Anne de la Pocatière, poursuit actuellement un "Post-graduate course" à l'Université de Toronto.

Mons. René Pomerleau, Inspecteur en maladies des plantes, a quitté le Département pour poursuivre ses études a l'Université de Paris.

A TRAVERS LES REVUES

La Simplification des Etiquettes d'Engrais Chimiques

Dans "The American Fertilizer" du 15 octobre 1927, nous trouvons une nouvelle manifestation de l'heureuse tendance vers la simplification dans la description des engrais chimiques, que l'on constate depuis un certain temps en Amérique. On rapporte qu'à une conférence tenue à St-Louis (Kentucky), réunissant un grand nombre de techniciens agricoles, de fabricants d'engrais commerciaux et de publicistes agricoles, il a été résolu d'apporter plusieurs modifications importantes dans la manière de libeller les étiquettes apposées sur les sacs d'engrais, de façon à leur oter toute apparence mystérieuse ou cabalistique vis-à-vis des cultivateurs.

C'est ainsi qu'il fut décidé de supprimer le terme *ammoniaque* pour ne conserver que celui *d'azote,* ce qui évitera à l'avenir les confusions résultant de cette habitude ridicule d'employer deux dénominations différentes pour désigner un seul et même principe constitutif des fertilisants. Ensuite fut discuté l'ordre d'énumération des trois éléments: *azote-, acide phosphorique* et potasse. A ce sujet il faut remarquer que dans les états du nord l'usage a toujours prévalu de les nommer dans l'ordre que l'on vient de voir plus haut, tandis que dans les états du sud, qui sont de grands consommateurs de matières fertilisantes, la formule est généralement libellée dans un autre ordre, le premier chiffre indiquant le P_2O_5, le second l'azote et le troisième le K_2O. Les fabricants marquant les engrais suivant les deux méthodes conventionnelles, il s'ensuit naturellement qu'on est souvent dans l'incertitude concernant la signification des formules. Considérant que le P_2O_5 constitue ordinairement l'élément le plus important des engrais composés, et que les états du sud le placent déjà en premier lieu dans la formule, il fut recommandé d'adoptr cet ordre dans tous les pays. En d'autres termes, au lieu d'écrire $N - P_2O_5 - K_2O$, on adoptera partout la formule $P_2O_5 - N - K_2O$, afin d'avoir une notation uniforme, évitant les confusions.

On insista aussi pour l'adoption de nombres entiers dans l'indication des pourcentages en éléments fertilisants, afin de faciliter la comparaison

entre les différentes marques d'engrais et l'établissement de leurs valeurs respectives.

Enfin, il fut question du terme anglais "acid phosphate", servant le plus souvent en Amérique à désigner le superphosphate. A ce propos on ne manqua pas de faire ressortir que cette dénomination est mal choisie parce qu'elle met les cultivateurs sous l'impression qu'ils ont affaire à une matière qui tend à augmenter l'acidité de leurs terres, alors qu'il n'en est rien, puisque l'acide sulfurique employé dans la préparation de cet engrais est entièrement transformé. Aussi fut-il fortement recommandé de rejeter le mot "acid phosphate", pour ne plus faire usage que ce celui de "superphosphate", adopté dans les autres pays.

A Propos d'hypotheses

A ceux que la valeur ou l'utilité des hypothèses laisse sceptiques ou qui se scandalisent pour de bon, en présence du fait que nombre d'hypothèses servant de support aux théories et systèmes scientifiques les plus courants sont très souvent fort douteuses et parfois manifestement fausses, nous dédions les considérations suivantes que nous extrayons d'un fort intéressant article intitulé "l'hypothèse atomique", paru sous la signature de A. V. Wendling", professeur de physique à l'Ecole polytechnique de Montréal.

"Personne ne demande plus aujourd'hui à une hypothèse scientifique d'être vraie ou fausse, mais d'être légitime et commode; d'être simple, de fournir le moyen de grouper des faits jusque là isolés et de suggérer des expériences nouvelles confrontables avec la théorie pour la vérifier numériquement; une hypothèse est avant tout une méthode de travail et l'on ne doit compter comme fait que ce qui peut être exprimé par un nombre".

EDITORIAL NOTES

Local Branches

A considerable number of local branch meetings have been held during the past month, several of which were attended by the President and General Secretary of the Society. Mr. L. P. Roy, the President, addressed meetings at Montreal, P.Q. on November 10th, Rimouski, P.Q. on November 16th, Toronto, Ont. on November 18th and Macdonald College, P.Q. on November 25th. Full reports of the meetings at Montreal and Rimouski are published in the French section of this issue.

The meeting at Toronto on November 18th, during the Royal Winter Fair, was held jointly with the O.A.C. Alumni Association. The principal speaker was Sir Robert Falconer, Principal of Toronto University, and the attendance numbered about 130.

Dr. James E. Boyle, Professor of Rural Economics at Cornell University, addressed the members of the Eastern Ontario local at Ottawa on November 24th on the subject, "The anarchy of agriculture," and the members of the Macdonald local on November 25th on the subject, "Recent co-operative movements in the United States."

The Alberta Branch held a meeting at the University of Alberta on October 27th, when Dr. F. A. Wyatt gave an illustrated address on, "Soils of Alberta." A number of business men in Edmonton, as well as the entire graduating class in agriculture at the University, were guests of the local branch at this meeting.

The Western Ontario local is now holding weekly luncheons, every Friday, at the Board of Trade Chambers, Royal Bank Building, Toronto. Any C.S.T.A. member who happens to be in Toronto on the day of these meetings is cordially invited to attend.

The North Saskatchewan Branch will hold a regular series of meetings during the coming winter, each meeting being held at the home of one of the members. The first meeting of the series took place on November 3rd, when Professor A. R. Greig gave a talk on "Electrification of the farm."

Notes and News

Dr. C. A. Zavitz (Toronto '86) is spending the winter in Florida. His address is Apt. 10, Court Park, 459 Second Avenue North, St. Petersburg, Florida.

H. A. Derby (Toronto '23) and J. W. Howe (Alberta '25) are taking post graduate work at the Iowa State College, Ames, Iowa.

A. J. G. Maw (McGill '23) is at Macdonald College, P.Q., taking special studies in Poultry Husbandry.

The address of W. C. Fawcett (Alberta '27) is Consort, Alberta.

George L. Art (Saskatchewan '25) has changed his address to 550 Fourth Avenue North, Saskatoon, Sask.

C. J. Watson (McGill '21) is spending the winter at Cornell. His address is 409 Dryden Road, Ithaca, N.Y.

H. C. Andrews (Manitoba '20) has changed his address to 14 Credit Foncier Building, Regina, Sask.

A. W. Peterson (McGill '21) has been transferred as District Sheep and Swine Promotor, under the Dominion Live Stock Branch, from Charlottetown, P.E.I. to 347 St. George Street, Moncton, N.B.

Gustave Gaudet (Laval '22) has had his office as District Representative transferred from Albertine to Edmundston. His address is Box 786 Edmundston, N.B.

J. E. McRostie (Toronto '14) has been transferred from the Maple Leaf Milling Company in Ottawa and is now Manager of their main plant at West Toronto, Ontario.

F. Dimmock (McGill '23) is with the Tobacco Division, Central Experimental Farm, Ottawa, for the winter months.

R. Pomerleau (Laval '24) is at 19 Boulevard Jourdan, Paris, France. He is taking special work in mycology at the Sorbonne.

Jules Simard (McGill '21) is now District Seed and Feed Inspector for the Maritime Provinces under the Dominion Seed Branch. His headquarters are at Sackville, N.B.

We regret to record the death of a Charter Member of the Society in the person of Earle C. Hatch (McGill '20) who died at Ste. Agathe des Monts on November 19th, after an illness of three weeks. He had been engaged for several years as advertising representative for a number of eastern agricultural journals. The funeral took place at Ancaster, Ont., on November 22nd.

Application for Membership

The following applications for regular membership have been received since November 1, 1927:-

Clyde C. Gillies (McGill, 1911, B.Sc.) R.R. No. 2, Strathcona, Alberta.

Adhemar Gratton (Montreal 1917, B.A.; 1920, B.S.A.), 6778 St. Hubert Street, Montreal, P.Q.

C. R. MacDonald Holmes (Alberta 1927, B.Sc. Agric.) Western Producer, Saskatoon, Sask.

Raoul Hurtubise (Toronto 1925, B.S.A.) Dominion Seed Branch, New Liskeard, Ontario.

W. G. le Maistre (Toronto, 1926, B.S.A.) Ottawa, Ontario.

Nelson A. Patterson (McGill 1927, B.S.A.) Dominion Entomological Laboratory, Annapolis Royal, Nova Scotia.

C. E. Russell (Michigan State College 1926, B.S.A.) Macdonald College, P.Q.

O. H. J. White (Toronto 1922, B.S.A.) Dominion Dairy and Cold Storage Branch, 1 Common Street, Montreal, P.Q.

The following copy of "Scientific Agriculture" is badly needed to meet requests for complete volumes:—

Volume VII. No. 8 - April, 1927.

If any member can locate this missing number and will mail it to P. O. Box 625, Ottawa, Ontario, he will be reimbursed at the rate of 50 cents per copy.